Chemical & Process Engineering

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Topics of the Month

Industry-university collaboration in training chemical engineers

DURING a brief trip to Switzerland recently we visited the Federal Technical Institute at Zurich, one of the world's foremost institutes of technology. Considerable expansion is taking place in the technical chemistry department under Prof. Guyer and we were particularly interested in the new building which is being fitted out for instruction in unit operations. It will soon be completely equipped with all the plant and apparatus necessary for the study of drying, heat transfer, fluid flow, distillation, mixing, etc. This new chemical engineering laboratory consists basically of a large hall with ample headroom for large equipment such as stills and evaporators and with a gallery for smaller plant like filters, refrigerators, drying ovens and mixers.

Although the laboratory is admirably designed and equipped, it did not impress us as much as did the laboratories at Delft Technical University (fully described and illustrated in our January 1952 issue). These laboratories are more elaborate than those at Zurich and, as we have commented, have installations big enough to produce a respectable output of chemicals, cement, etc. Whether this, in fact, is being done we do not know, but we commend it as a good idea. Surely it must give a student an entirely new interest in his studies if he knows that the product he is making will, in fact, be used instead of being poured down the drain. Admittedly such an arrangement would require careful supervision in the case of the less advanced students, but this is all to the good. It seems to us that the knowledge that he is actually making chemicals that will be used while at the same time pursuing his studies would give a student a psychological fillip which would be invaluable.

Who would buy the products? This question leads us to a second idea. Would it not be possible for some enlightened firm to arrange to have certain of its smaller lines made by a university or technical institute? We have in mind chemicals that are bought by the pound. Instead of paying cash, let the firm give equipment and raw materials and, perhaps, some technical instruction by its production chemists and engineers.

This scheme may sound far-fetched and hopelessly impracticable. Perhaps it has been thought of before and discarded, but if so let the reasons for its rejection be re-examined with these thoughts in mind: (1) the students would benefit psychologically by working on some real production while still at college; (2) the university would benefit by getting raw materials, equipment and other practical support from industry; and (3) industry would benefit by helping to train a new generation of chemical engineers while at the same time making what would otherwise be purely 'instructional' plant earn its keep. There may be many snags and, perhaps, many good reasons for completely dismissing the scheme. Whatever our readers think we would like to have their views, preferably for publication.

More scientists required

ALTHOUGH at present there are some half a million unemployed persons in Great Britain, there are far too few graduate scientists, technicians and skilled workers to fill the jobs that are open to them. This shortage is not temporary, despite the fact that the number of students studying pure and applied science at British universities has more than doubled since the war. The contemporary trend in industry is to increase the value of plant used per man employed. Today this index in the United States is twice that in Great Britain and any improvement in the British figure demands a corresponding increase in the proportion of high-grade to low-grade staff. A more skilful labour force is required also if we are to produce significantly more with existing plant. In either case the number of scientists in industry must be increased.

Scientific manpower is discussed in the recently published fifth annual report of the Advisory Council on Scientific Policy, 1951-52 (H.M.S.O., price 6d.). It is concerned with these problems: (1) the supply of and demand for scientists; (2) steps to increase the supply; (3) the quality of scientific manpower; and (4) steps to improve that quality. After a study carried out with the Ministry of Labour and other organisations, the general conclusion is that there is likely to be a shortage for a long time of practically all kinds of scientists, and that every effort should be made to increase the supply, particularly of chemists, chemical engineers, electrical engineers, mechanical engineers and physicists. In the section on chemical engineers it is pointed out that the report of the Anglo-American Council on Productivity on 'Universities and Industry' specially mentioned the American courses in chemical engineering. In 1949-50 the number of American first degrees in chemical engineering was 4,529, whereas the number of corresponding British degrees was very much smaller, even taking into account the small size of our population relative to the American. In the past many posts which should have been held by chemical engineers have in fact been filled by chemists or engineers and British industry is now coming to realise the value of the chemical engineer. Many believe that the large number of chemical engineers in American industry has been an important factor in its rapid progress.

Many students with the ability to reach a university standard leave school before the age of 17. The first step towards increasing the supply, therefore, is to get more of these to remain at school until nearly 18. This problem is not so easy to overcome as may appear. First there are too few good science teachers and special measures may have to be taken to increase their number at the expense of what may appear to be the more immediate demands for scientists in industry and research. Furthermore, science does not attract as many public school boys of outstanding ability as is desirable. There are two reasons for this. The ablest boys are often attracted to the subjects taught by the more outstanding masters and, in public schools, these are more likely to be non-science teachers. Also, too little is known of the great opportunities for scientific, and especially engineering, training available in universities other than Oxford and Cambridge. At the other end of the scale, many parents do not yet realise the value of further education and prefer to send their children out to work at an early age, although many could get financial assistance for university education.

There has been remarkable unanimity among the Advisory Council's informants that, although present-day science graduates are adequate as scientists, they tend to lack a sufficiently broad education, not only in the general sense but also in the field of science. It is recommended that this matter should be considered further by the universities and other training institutions, including the technical colleges.

Clearly what is needed as well is the further expansion of facilities for scientific education in the universities. This problem has been widely discussed during the past six years, and now the need is generally conceded, although the method by which such expansion is to be brought about—whether by the creation of new technological universities or by expansion of science faculties in existing universities—has yet to be settled. The Advisory Council are emphatic in urging speedy expansion in the national interest.

World helium producer

UP to the beginning of the year, the U.S. Government's helium plants had produced a total of 1,000,000,000 cu. ft. of helium. To reach this amount, more than 100,000,000,000 cu. ft. of natural gas, which contained a small percentage of helium, was processed. The U.S. is the only country known to produce helium in large quantities and the Bureau of Mines is the only producer in the U.S.A.

Today the Bureau operates three helium plants—two in the Texas Panhandle, one near Amarillo and one at Exell, and another at Otis, Kansas. It also maintains a standby plant at Shiprock, New Mexico. Production of the Amarillo plant started in 1929 after it had become apparent that the gas field which supplied the Fort Worth plant was nearing depletion. From 1929 until March 1943 the Amarillo plant was the only helium-producing plant in the world. The Exell plant, constructed in 1943, has been in constant production since that time and has turned out about one-half of all the helium ever produced in the world. The Otis and Shiprock plants were also built during World War 2.

Before World War 1, helium had been produced on laboratory scale at a rate of about $2,500/cu.ft. Today's price is only about 1½ cents/cu.ft.

About 30% of the current production is used by private industry, mainly for shielded arc welding. Present production capacity of the four Government plants and the known reserve potential are enough to meet all foreseeable demands for many years.

Helium was one of the rare gases discovered by Sir William Ramsey, who was born in Glasgow exactly 100 years ago.

5½ million tons of nitrogen by 1954

THERE was a world surplus of production over consumption of 67,000 tons of nitrogen, or 1.3%, for the fertiliser year ending June 31, 1952, according to the half-yearly report on the nitrogen industry recently issued by Aikman (London) Ltd. This is only a small surplus and projects are under way throughout the world to enlarge existing production facilities to meet the expected increases in consumption. By 1954-55 world production for agricultural purposes is likely to reach 5,515,000 metric tons of nitrogen, which is more than 1,000,000 tons more than at present.

Estimates of U.S. consumption by 1954-55, given by Government sources, indicate that by that date their requirements of nitrogen will be 2,640,000 metric tons, or 890,000 tons more than the estimated consumption for 1951-52. This figure would represent an annual increase of about 17%, but Aikman's consider that such a large increase is improbable and estimate that annual increases of 6% for

Europe and Egypt and 9% for the U.S.A. and other countries are more likely. During the past six months schemes have been prepared for a further extension of U.S. production capacity by 350,000 tons of nitrogen by 1954-55, in addition to the 600,000-ton increase announced some months ago.

In India, during the first six months of this year, the Sindri plant reached a monthly production of about 15,000 tons of sulphate of ammonia, owing to heavy stocks of gypsum having been accumulated before production started. The difficulty of getting sufficient gypsum in the future may cut down production by 50%.

Apart from the U.S.A. and India, new plants have started, or are planned, in Egypt, Spain, Portugal, Finland, Bulgaria, Israel, Mexico and possibly Greece, with extensions to existing plants in Italy and France. The total increase in production outside the U.S.A. by 1954-55 over 1951-52 appears likely to reach about 300,000 metric tons of nitrogen, a figure which is slightly less than the U.S. proposed expansions. Production in Russia is estimated at 250,000 tons p.a. of nitrogen, but a subsequent publication in Moscow mentioned that new plants had been erected in Central Asia, with a considerable increase in the use of fertilisers in Russia, so that the above estimate may now be too small.

Canteen management

SINCE 1943 it has been compulsory for factories in Great Britain employing more than 250 people to establish canteens to provide hot meals for their employees. As a consequence there are now more than 30,000 factory canteens in the U.K., of which about 80% are managed directly by the companies concerned. Therefore, there should be very wide interest in a new book on the management of factory canteens which constitutes a practical guide to the material, economic and human problems involved in running both large and small canteens. It has been written by Jack Hampton, catering manager of Guest Keen & Nettlefolds (South Wales) Ltd., and it is published by Leonard Hill Ltd., London (pp. 126, including index, illustrated, 15s. net).

There are 25 chapters dealing, among other things, with balancing the budget, canteen licences, management methods, kitchen equipment, canteen furniture, tea handling, crockery-, cutlery- and dish-washing machines, food purchasing, stores, canteen bakeries, special diets, cleaning, food poisoning, factory regulations, entertainment in canteens, the company shop, industrial hostels, works sports clubs, and the history and future of the factory canteen. Over 500 references appear in the 10-page index.

Since 1939, prices in British canteens have hardly been increased and are now about half those paid in some public restaurants. In view of the almost 100% increase in wages and the increased cost of food, serious attention is having to be paid to reducing the running costs of canteens, many of which are heavily subsidised by the company or other organisation concerned. This book will be an eye-opener to the many persons connected with the running of canteens. Although the opening sentence states that the key to the finance of the factory canteen is the price of tea, after reading the book one is left with the impression that crockery breakages, both accidental and wilful, pilfering of cutlery and forging of canteen food tickets are possibly more responsible for the losses incurred and that considerably more attention should be paid to these matters.

The author stresses the need for good capital investment. The operating capacity of potato peelers, etc., should be high enough to deal with demands. Stainless-steel sinks, table and kitchen ware are highly recommended and although they are more expensive than other kinds they pay for themselves by lasting longer and requiring little maintenance.

There is an enlightening section on personnel and the author has obviously had wide experience in this field. A great deal of work in kitchens is carried out by persons of relatively low intelligence and one of the canteen manager's tasks is to ensure that his staff fully appreciates the need for correct handling of electrical and mechanical equipment, both for the sake of their own safety and to reduce damage to equipment.

Bulk purchasing of food is advocated and many rewarding suggestions are made, such as buying fish straight from the port and not from local dealers.

This book will be an asset to all connected with the running of canteens. Its price will be amply repaid by the numerous and varied practical suggestions for more efficient running which should assist canteen managements to cut running costs in order to meet increased expenses without the need either for raising prices or increasing subsidies.

New gas purifying process

A NEW and cheaper method of removing carbon dioxide from synthesis gas has been developed in the U.S. Removal of carbon dioxide from the gas is a necessary step in the production of synthetic liquid fuels from coal by the gas-synthesis process. This is one way of producing oil from coal and oil shale being studied by the Bureau of Mines in its continuing synthetic liquid fuels research programme.

Developed by J. H. Field and H. E. Benson, chemical engineers in the Synthetic Liquid Fuels Research Branch of the Bureau of Mines at Bruceton, Pennsylvania, the new method employs a hot, concentrated solution of potassium carbonate to absorb the carbon dioxide. Absorption occurs at pressures of 300 to 600 p.s.i., which are used in the gas-synthesis process. The carbonate solution is regenerated by pressure let down and steam stripping at substantially the same temperature used in the absorption step. This eliminates the need for heat exchange treatment, used in the conventional method, and reduces the amount of steam consumed in the process.

As synthesis gas is the major cost item in producing synthetic liquid fuels from coal by the gas-synthesis process, any improvement that reduces the expense of purifying the gas is a definite advance towards the day when production of oil from coal on a commercial scale will begin. It is expected that the new method will also be used in other processes, notably the production of synthetic ammonia from either coal or natural gas. Because of the large volumes of carbon dioxide that must be eliminated in synthetic ammonia production, Bureau technologists feel that the improved process should be very valuable to this rapidly expanding industry.

The laboratory work and pilot-plant tests that led to the development of the improved method formed an integral part of the Bureau's overall synthetic liquid fuels programme, and the process has been filed for patent in the name of the United States Government.

Versatile molybdenum

THE new Ministry of Supply order calling for strict economies in alloy steels containing molybdenum,* which became operative at the beginning of June, is a re-

*See CHEMICAL & PROCESS ENGINEERING, May, p. 266.

minder of the many demands for this versatile metal in a number of fields. The pure metal, second to tungsten in strength at temperatures above 900° C., became applied not only in supports for tungsten filaments in lamp and vacuum tubes, but also became ' the metal that talks,' as the Americans describe its indispensability for filaments, grids and screens of radio valves. Though like tantalum the metal must be protected by inert gas or refractory when taken to any appreciable temperature, molybdenum thermocouple tubes and furnace-heating elements have been well developed, such wire-resistors appearing in the production of molybdenum metal itself in those processes of powder metallurgy in which the Fansteel interests took a prominent part. Alloy steels, including invaluable molybdenum, have occupied a whole book to themselves, for nitriding steels in particular require much molybdenum. In recent years 4% molybdenum with 6% tungsten answered a tungsten scarcity by replacing the high content of tungsten (16-22%) previously favoured, while up to 7% molybdenum goes into steels for turbo-supercharger blades and other gas-turbine parts. The new Ministry restriction prohibits such richer molybdenum steels except when specifically approved.

Modern applications include well-established ones, as with molybdates for analysis, for fire-proofing, for dyeing wool and silk, in glazes and pottery, and also as molybdenum oxide catalysts; and newer ones like alloys for tipping gold nibs, in acid-resisting alloys, molybdenum traces in brightening zinc plating, and others.

Molybdenum history took a long time to develop after Qvist obtained ' yellow snowflakes ' or crystalline laminæ on calcining a strange mineral in a furnace 200 years ago. Scheele's friend, Peter Hjelm, prepared a crude molybdenum metal by carbon reduction of molybdic acid after Scheele himself had described *molybdenae* or ' lead ore ' which was ' different.' Scheele ' rejoiced ' at the discovery of yet another element to the chemist's list, little realising what a versatile element it was to prove.

Hydrogenation's half-century

THERE have been many developments in the industrial aspects of hydrogenation since Normann took out his patent in 1902. The 'hardening' of oleic acid was first attempted using phosphorus and iodine and then potash fusion, the latter actually being worked by Radisson at Marseilles. Liebig, Fokin and others experimented on palladium and platinum as catalysts; Mond hinted at nickel in 1888—but rather for dehydrogenation uses.

Sabatier and Senderens then began their classic experiments on hydrogenation of unsaturated compounds, though these referred to the vapour phase, while in 1901 the patent of Senderens specifying nickel also mentioned palladium, cobalt or iron, and was still rather academic in outlook, since such reductions as nitrobenzene to aniline were envisaged.

All credit must thus go to Normann for using nickel in the hydrogenation of liquid oils as an alternative to vapour phase methods, for studying nickel on inert carriers or supports, and for demonstrating nickel powder as a catalyst when formed *in situ* from nickel oxide suspended during hydrogenation.

Normann converted oleic to stearic by this means and also treated the fatty acids of tallow to yield an acid with iodine number 10 in place of the original 35. In studying hydrogenation by nickel acetate, formate, stearate and oleate he found the pure acids liberated; hence his conclusion that free nickel must be liberated before oil hardening takes place.

That the food industries owe much to Normann with his practical outlook is realised by further references to his studies of the nickel content of hydrogenated oils and of methods of removing nickel. He proved that only two parts nickel per million were present in treated oils, that is, no more than in oils treated in nickel-lined plant. Normann's nickel kettle for this work and his estimations with dimethylglyoxime round off a remarkable harnessing of the one-time ' Old Nick's Metal.'

Iron in Labrador

PROVEN deposits in the Ungava iron ore fields, Labrador, amount to 400,000,000 tons, the ore containing 55 to 65% iron. Investigation of these deposits was first started in 1947 and the exploitation project is the biggest structural programme ever undertaken in North America. Situated in rugged, undeveloped country, the mines are 360 miles inland from Seven Islands, a village on the north bank of the St. Lawrence river.

A $95,000,000 railway is being built between Seven Islands and the iron fields. At first, every item of equipment was delivered by air, including 40,000 lb. mechanical scrapers and 27-in. shovels. By October of last year, air-freighters had delivered 5,000,000 lb. of heavy mining and railway constructional gear to operating points along the railway. The ore will be crushed at Burnt Creek, where it will be stockpiled pending the completion of the railway to Seven Islands.

Capital expenditure on the Ungava project includes $5,000,000 for mining machinery. Equipment comprises 6½-yd. scrapers, 5½-cu. ft. electrical shovels and a fleet of heavy duty trucks and conveyor belts for delivery of the ore to the crushers and ore trucks. Individual truck loads will be analysed to meet consumer specifications, the analysis being teletyped ahead of each train load to Seven Islands.

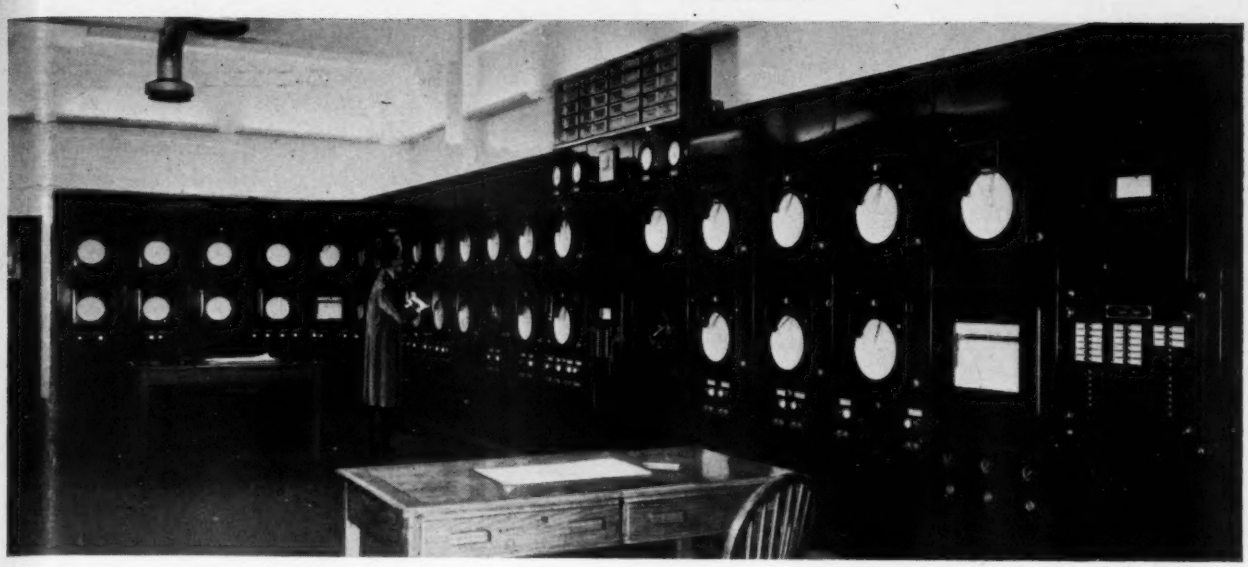
Mining will be from open pits. The project is scheduled to come into operation in the summer of 1955 and the aim is 70,000 tons of ore mined every 24 hr., with an ouput rising to 20,000,000 tons a year, twice as much as was originally planned (see this journal, January 1950, p. 14). However, it will not be possible to export to Britain until 1957, when it is expected that the output will have reached 8,000,000 tons p.a.

The Ungava mines will only be operated during six months of the year as the St. Lawrence river is only open to shipping during that period.

The project is being run by the Iron Ore Co. of Canada, which was formed by six leading American iron and steel companies and a Canadian company.

Contributions

THE EDITOR *welcomes practical articles and notes on chemical engineering and industrial chemical subjects with a view to publication. All contributions, which should be fully illustrated whenever possible, are carefully considered. A preliminary letter or synopsis is advisable. Address such material to* THE EDITOR, CHEMICAL & PROCESS ENGINEERING, 17 Stratford Place, London, W.1.



Automatic Control in the Process Industries

By Alan Pollard, B.Sc., A.R.I.C.

Chemical and process plant lends itself ideally to automatic control and during the past ten years, as plants have become more complex, there has been increasing use of automatic controllers. Indeed, some modern chemical plants would not be in existence if their designers had not been able to make use of control instruments, the range and efficiency of which are continually increasing. Because of the importance of the subject to chemical engineers, we have commissioned three articles in which modern concepts and systems will be described. In this first article, the author discusses the objects of automatic control, the concept of the closed loop, and the present status of process analysis and measuring and controlling instruments.

PROBABLY the most important factor in the management of British industries since the war has been the necessity of raising output to meet the increased demands of both the home and export markets. To keep sales at a high level production costs must be kept down, without, however, reducing standards of living or the quality of the product. At a time when the essential raw materials and fuels are in short supply, and the costs of both labour and materials are tending to rise, the problem of reducing production costs is a complex one. Many attempts to increase output and reduce costs have been and, indeed, still are being actively investigated and applied. These measures include the standardisation of production plant and equipment; the rationalisation of production programmes, *e.g.* by longer production runs on one type of product; time and motion studies; cash incentives for workers and improvements in working conditions; and many other methods of increasing the overall efficiency and economy of the process.

In the latter category a very powerful aid has been the extended use of instrumentation and, in particular, the increasing application of automatic control in the process industries.

Objects of automatic control

The object of using automatic control in any industrial application has been very well summarised by the two words, **greater productivity**. However, the popular assumption that this is immediately effected by the elimination of the human operator is quite wrong. This is particularly the case in the chemical and process industries, where a process control can never totally replace the human element, some supervisory function at least being required always. Of course, cases can be cited in which the duties of an operator can be reduced so much by the use of automatic control that one operator can do the work formerly done by several people. But in most chemical plants a minimum number of operators will be required on the plant at all times, and this number is not likely to be reduced appreciably by changing from manual to automatic control. For example, the minimum number of operators in a particular area should never be less than two, since a single operator can be incapacitated by a very simple accident. However, it is often possible to redeploy labour by the use of automatic control. It must be remembered that the manual operator has, in fact, two major duties to perform; the first is the obvious one of controlling the plant, *i.e.* to maintain certain desired values of the process variables. The second, and less obvious duty, is that of maintaining the conditions of normal operations by preventing disturbances and to restore such operating conditions after any inevitable disturbances. Such disturbances are caused in the ordinary course of operations by such factors as changes in the quality of raw materials, failures in power and water supplies, corrosion and deterioration of the plant, and the like. The manual operator, in fact, must devote part of his time to frequent inspection of the plant for the early detection of leaks and mechanical wear, and is often also responsible for routine pumping and stock transfers.

The control room of the 'Santomerse' detergent plant of Monsanto Chemicals Ltd. at Newport is shown in the above photograph. Temperature, pressure, vacuum, depth and flow recorders are arranged along all four walls. Above the central panel is the enunciator board, which lists each stage of the process by name. Should any breakdown occur in the plant, a light appears on the appropriate panel to show the site of the trouble. Coloured lights also indicate the stage which each operation has reached, and there are safety controls which operate automatically in any emergency.

The automatic controller is installed to carry out the first of these duties; it can generally do so better than the manual operator and especially over long periods. It can also deal, usually adequately, with disturbances such as the normal changes in process load or the gradual deterioration of plant, *e.g.* the fouling of heat transfer surfaces. But the controller cannot deal with the other disturbances mentioned above—it cannot re-adjust its desired value to suit changed conditions of operation—and, although the present automatic controller is as reliable as any other instrument, failure is still possible. Some of these factors might be covered by alarm signals, but intelligent supervision is still required. Using the controller, however, will improve the quality of control of the plant and the operator will be relieved of many routine duties so that he can spend more time on keeping the plant in efficient operation.

Generally, the major effect of automatic control on labour will be to obtain better control with less physical and mental effort on the part of the operator. On the larger and more complicated plants where the control instruments are generally centralised, the actual operational control of the plant can be concentrated in the hands of a relatively few highly skilled supervisors. The routine duties necessary on the plant are diverted to 'outside' men, generally less skilled, who report back to the central control room. By this redeployment, much better use can be made of the available labour force and in some cases it may be possible to use a greater proportion of the less skilled labour. On the smaller plants, control is not centralised to such an extent and the operator will generally combine his supervisory duties with the routine jobs on the plant. But by eliminating much of the monotony and physical effort associated with manual control, the operator's working conditions and hence his sense of well-being and efficiency can be improved.

However, in the process industries the labour costs, although important, do not generally form such a high proportion of the total production costs as in other industries where the output per man hour is usually much less. Thus the reduction of labour costs is not so important as is the increasing of the output per man hour still further. It is in this direction that automatic control can make the biggest contribution to greater productivity. Greater productivity means more efficient use of the plant. Automatic control allows the stabilising of the operating conditions within closer limits and over longer periods than is possible with manual control alone. By this alone the quality of the product can be held to closer limits and the proportion of rejects reduced, but the effect of greater importance is that, by eliminating peak values of the operating variables, it is possible to operate much closer to the ultimate capacity of the plant, and often the plant throughput can be materially increased. Since temperature peaks, pressure surges, excessive changes in concentrations of liquors and the like are limited and the control in general is smoother, the maintenance of the plant is reduced and the need to replace equipment becomes less frequent.

In designing new plants the size and cost of surge vessels can be reduced by the use of automatic control, which also makes possible considerable economies in the layout of pipework, since control valves can be placed in the most suitable position on the plant, access only being necessary for maintenance. A manual control valve, on the other hand, must be brought to an operating platform at a suitable point, thus increasing the run and cost of the pipework.

The advantages inherent in automatic control naturally become more important as the complexity of the plant increases and the manual control more difficult. In a complex process, where there may be a large number of interdependent variables all requiring separate control, manual operation becomes almost impossible. The fact that so many processes of this type are now operating so efficiently is due solely to the successful application of automatic process control.

Economic considerations

Unfortunately, very little information has been published on the economic aspects of the subject. The chief difficulty lies in obtaining reliable figures which can demonstrate unequivocally the financial savings directly attributable to the use of automatic control. Obviously, comparisons of this nature can only be based on a plant before and after its conversion to automatic control. Unfortunately, the addition of instruments to an existing process is not usually made on any particularly sound economic grounds but rather on some functional property of immediate value such as an improvement in the quality of the product. As a result, instruments added to an existing plant serve mainly as useful additions and not generally as integral parts of the process when their economic value would be much greater. Too often, also, there are obscuring factors such as changes in the plant design or even changes in plant personnel which may affect the result. It is also rather doubtful if comparisons of this nature would serve a very useful purpose, since they would be restricted to the one particular plant under its own peculiar local conditions and could not be generally applicable even to similar types of plant.

In the case of new plants it is now almost axiomatic to specify the need for automatic control at the design stage, again for its purely functional value, in much the same way that measuring instruments are specified for manual control, experience suggesting what functions are required without much regard for any financial benefits which accrue from their use. However, by integrating the automatic control into the process at the design stage, economies in the capital cost can be made, but as yet the plant designer cannot take full advantage of the potential benefits of using automatic control. At the moment there is not enough basic information available on plant characteristics with regard to control, due to lack of knowledge in other branches of chemical engineering as well as in the theory and practice of control applications. It should not be long, however, before plants can be designed for automatic control in the fullest sense of the term.

Estimates of capital costs of instruments vary widely; quoted figures range from 2 to 10% of the total capital cost of the plant. This, however, is mainly due to lack of a suitable definition of what constitutes an instrument; in some cases valves and positioners may be included, in others these may be regarded as ancillary to the actual controllers. Maintenance and depreciation costs depend very largely on operating conditions and also on the size of the establishment, and estimates could be misleading.

General considerations of the control loop

It is not intended in this article to discuss the principles governing the application or selection of automatic control equipment, or the theoretical aspects of the subject. These topics have received considerable attention in the recent years and reference should be made to the literature. In the present instance it is hoped to review the general position of automatic control in the process industries with particular attention to some of the present difficulties. However, before embarking on this discussion it will be advantageous to review the basic generalised control problem.

Every automatic control system, irrespective of the application, forms a completely closed loop circuit as shown in the generalised block diagram of Fig. 1.

The measuring unit measures the instantaneous value of the controlled variable as detected by the detecting element attached to the plant. This information is passed to the controlling unit, generally by a direct mechanical linkage, the controller and the measuring unit being combined in the same instrument. In the more recent instruments the measuring and control functions are entirely separate and the connection may be either electrical or pneumatic. In the majority of cases in the conventional instrument, the instantaneous value of the controlled variable will also be indicated and/or recorded by the monitoring unit, which may also form an integral part of the instrument. This unit, however, is not essential to the operation of the control system, but is generally advisable for supervision of the performance.

The controlling unit compares the instantaneous value of the controlled variable with the desired value and adjusts the regulator in such a manner that the corrective action applied to the plant reduces the

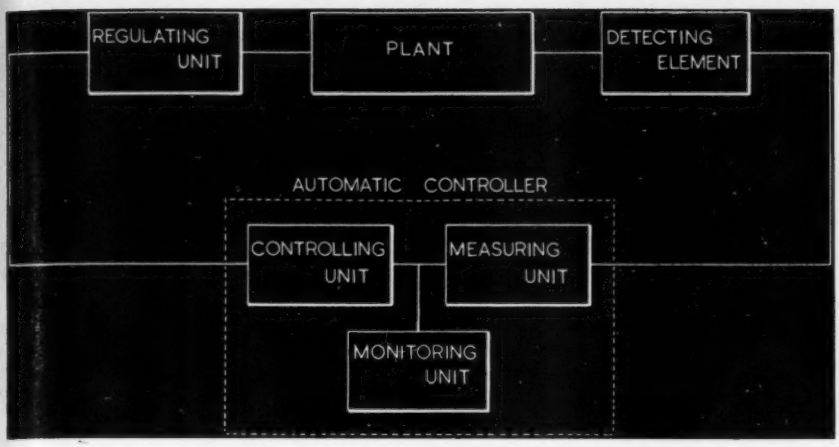


Fig. 1. Generalised diagram of automatic control closed loop.

difference between these two quantities to a minimum. The desired value of the variable may be set either manually or automatically by adjustments within the controller.

The regulating unit is the apparatus capable of effecting changes in the controlled variable by varying the flow of material or energy into the plant and so changing the material or energy balance. In the majority of cases in the process industries the regulating unit will be a control valve, but it could be a rheostat in an electrical circuit or a variable speed gear on a pump or machine.

Finally the process or plant forms the connection between the regulating unit and the measuring unit and so 'closes' the control loop. The relationship between a change in position of the regulator and the response of the controlled variable is entirely a property of the plant and the characteristic lag in response mainly determines the ease or difficulty of the control problem.

Each part of the control loop is an integral part of the system and the characteristics of each must be considered of equal importance. Unfortunately, although the characteristics of the measuring system, the controller and the regulating unit are well known or can be deduced with some certainty, it is only in relatively simple cases that the characteristics of the plant can be predicted with any accuracy.

It will be readily appreciated that a manual control system also exhibits a characteristic closed loop, the manual operator taking the place of the controller and the connections to the measuring instrument and the regulator being replaced by the operator's eyes and hand respectively. In this case the characteristics of the operator enter into the performance of the system and, of course, are almost completely unpredictable!

Process characteristics

The characteristic property of the process is a lag in transmission of a signal from the regulator to the measuring element. This 'process lag' is mainly due to the presence of resistances and capacities in the plant, *e.g.* in a thermal process, the resistances to heat transfer and the thermal capacities of the various parts of the heat exchanger and the fluids involved. The exact arrangement of these quantities and their interdependence on one another is rarely immediately obvious, but the overall result can be determined on an existing plant with a fair degree of accuracy.

However, as mentioned previously, in the design stage it is not yet possible to use a fundamental approach which would permit the accurate prediction of the control requisites. At the moment the approach must be more or less empirical, controls which are thought likely to be required are chosen and then, when the plant is in operation, the controls are modified in the light of operating experience. The modifications likely to be required will generally be of a fundamental nature, repositioning of the measuring element, improvement of sampling methods, etc.

Probably the most important recent development in the study of process control characteristics is the application of frequency response analysis. Previously plant characteristics have been investigated by the application of step-function disturbances to the plant, *i.e.* by an instantaneous displacement of the regulating unit with the control loop broken at the controller. The response of the controlled variable, as detected by the measuring unit, is a transient disturbance of an exponential nature. The analysis of this transient response is by no means easy, but Ziegler and Nicholls[1] have shown that, by considering the response to consist of a time delay and a linear rate of change, it is possible to deduce empirical values for the desired controller adjustments. The application of this method is undoubtedly of some value in practical cases, but is limited in scope, it does not take into account the design of the controller and is of little value in design work.

In frequency response analysis of an existing plant, the control loop is again broken at the controller, but the disturbance imposed on the regulator is sinusoidal. The response of the measuring unit is also sinusoidal and of the same frequency, but in transmission through the plant, the amplitude of the sine wave is reduced and the wave subjected to lag in phase compared to the input wave at the regulator. The attentuation of the wave and the phase lag produced are uniquely determined by the characteristics of the plant and the frequency of the oscillation. By repeating the experimental measurements over a range of frequencies, the attentuation and lag corresponding to given periods of oscillation can be found and these quantities can be directly related to the controller adjustments.

Under closed-loop conditions, as in actual operation of the control system, a continuous oscillation of the controlled variable, the well-known phenomenon of 'hunting' or 'cycling,' can only be propagated by regeneration within the system. The attentuation caused by transmission through the plant is offset by the amplification effect of the controller, and the overall phase displacement of the whole loop must be 360°. The latter is made up of a phase displacement in the controller and the phase lag in the plant. That in the controller is inherently 180°, but can be advanced or retarded by adjustments of the controller actions. By fixing the phase shift of the controller at a given amount, the plant attentuation and the frequency of oscillation are determined solely by the plant characteristic and are therefore also fixed. It only remains to adjust the controller amplification factor (the 'gain'); if this is made equal to the plant attentuation, then the oscillation is made continuous, and if less, then the oscillation will be damped and die away. It is actually possible to predict from the frequency response analysis the controller settings required for any given degree of stability and also to predict the actual behaviour of the control system after a given disturbance.

This treatment is essentially that developed in the related field of electrical feed-back networks and servo-mechanisms, the only difference in these fields being the time scale involved. The theory has been successfully extended to process control in the recent text by Farrington.[2] The theoretical treatment is necessarily rather complex, but a simplified approach on which both the instrument and process engineers can work is presented by Rutherford[3] and Aikman.[4] By the use of a graphical representation a convenient measure of plant controllability and controller reaction can be obtained. This diagram can be determined experimentally by the use of an analysing instrument on an operating plant,[5] but Rutherford has also indicated that the response of simple elements of the plant can be estimated in the design stage and combined to give an

Table I. Process control actions

Type of action	*Equation*	*Characteristics*
1. Two-position	——	Inherently cyclic, requires slow process reaction.
2. Proportional	$\Theta = -\mu\theta$	Inherently stable, but subject to offsets produced by load changes.
3. Proportional-derivative	$\Theta = -\mu\left(\theta + R\frac{d\theta}{dt}\right)$	Offsets reduced, recovery time and overshooting decreased.
4. Proportional-integral	$\Theta = -\mu\left(\theta + \frac{1}{S}\int\theta dt\right)$	Offsets eliminated, recovery time and overshooting increased.
5. Proportional-integral-derivative	$\Theta = -\mu\left(R\frac{d\theta}{dt} + \theta + \frac{1}{S}\int\theta dt\right)$	Offsets eliminated with minimum recovery time and overshooting

'Offset' = A constant deviation of the steady-state value of the controlled variable from the desired value.

'Recovery time' = The time of transient response following a process disturbance before the establishment of a new steady-state condition.

'Overshooting' = The maximum deviation from the desired value following a process disturbance.

overall characteristic of the whole plant. In this estimation, experience of existing plants must play an important part; the accuracy can be expected to improve as more existing plants are subjected to the experimental analysis. This should certainly provide a foundation to the more fundamental approach to the design problem.

Measuring instruments

Apart from the plant itself, the major factor in the application of automatic control is the selection of the measuring element. Assuming that the reaction of the plant is favourable, any process can be controlled to some extent, but only if the necessary variable can be measured. It is also, of course, apparent from the nature of the control loop that it is the **measured** value of the variable which is being controlled and the ultimate closeness of control will depend finally on the measuring element.

The two major difficulties found in practice are measuring lag and unsuitable design of the measuring element for the working conditions. Measuring lag, the slow response of the element following a change in the magnitude of the variable, must always be present to a greater or less extent. It is exceptionally difficult to reduce in temperature measurement and in such cases as gas or liquid analysis where samples are withdrawn from the main process stream. The existence of a time lag in measurement implies also an **error** in measurement whenever the variable is changing. It is also apparent that the slower the response, the less chance will the element have of attaining equilibrium with rapidly changing conditions. The second factor, unsuitable design for the working conditions, often contributes to measuring lag, especially in temperature measurement. The most usual problem in chemical plants is corrosion and the provision of protecting sheaths increases lags considerably. The need for robustness to withstand vibrations, overloads, etc., also often necessitates a measuring element with reduced sensitivity and increased lag.

To minimise the effects of measuring lag two courses of action are available. The first is to increase the sensitivity of the measuring instrument, *i.e.* to give a larger signal to the controller. With many modern instruments it is possible to suppress the zero and provide a much more open scale about the usual desired value. The second method, which may in any event also be required by the plant characteristics or the closeness of control required, is the use of derivative action in the controller.

For probably the great majority of applications, standard measuring equipment can be used to give satisfactory results by the present standards, although all suffer from the incidence of measuring lag to a greater or less extent when made sufficiently robust for process use. In general, temperature, pressure, flow, liquid level, and a fairly wide range of analysis measurements are adequately covered. Yet there are still some notable exceptions even in these cases. It is not, for instance, possible to measure the flow of a boiling liquid or one which is releasing entrained gases; pulsating flows present considerable difficulties and there is no really satisfactory means of measuring the flow of solids other than by continuous weighing methods. The measurement of temperature of moving bodies below the limits of the radiation pyrometer, and the level of solids in bins are other notably difficult measurements.

The worst problem of measurement occurs when there is no physical variable on which the control of the process can be based. It should be remembered that most measurements in process work are only indirect measurements of a particular state of the process, *e.g.* temperature is frequently measured as an indication of composition as in a fractionating column, or of the degree of conversion in a catalytic reaction. Cases do arise, most frequently in batch processes, where manual control has been based on purely chemical tests made at more or less frequent intervals. In order to employ automatic control these chemical tests must be replaced by the indirect measurement of some physical variable bearing an empirical relationship to the required state of the process. This measurement must be capable of being made continuously and have a suitable output for operating the controller as well as being truly representative of the state of the process. It is often possible to use methods of physical analysis or electrometric methods or even such variables as density, etc. Only recently a very ingenious method of continuous electrometric titration was described for a process of this nature.[6] But in spite of the application of considerable ingenuity, processes will still be found in which the control must be based on purely chemical tests which must be performed manually. This will generally mean that automatic control cannot be used. Fortunately, such cases are the exception rather than the rule.

The controlling unit

The purpose of the controlling unit is to apply to the plant a corrective action whenever a deviation is detected between the measured and desired values of the controlled variable, the action being such as to reduce the initiating deviation to a minimum, or to zero if an integral component is present in the controller action. Most readers will be familiar with the general types of control action used in process control; the subject is adequately discussed in most of the standard texts on automatic control. No attempt will be made, therefore, to discuss these actions in detail, beyond the summary of the major characteristics of the most common actions presented in Table I.

The selection of the type of action to suit a given plant will depend upon both the process characteristics of the plant and on the quality of control which is required. No definite rules can be laid down, but in general the greater the process lags and disturbances and the 'tighter' the control required, then the more complex will the control action have to be.

The development of controlling instruments was severely impeded by the war and is only now really getting under way. During the past few years most of the pre-war versions of the pneumatic controllers have been remodelled with improvements both in design and performance. The operation of several of these instruments has been discussed by Young.[7] Several completely new instruments have also been placed on the market, some of which are radical departures from previous practice in controller design. It is hoped to discuss these newer instruments in a later article.

These developments promise well for the future. The British instrument industry is progressive and flourishing as visitors

(*Concluded on page* 366)

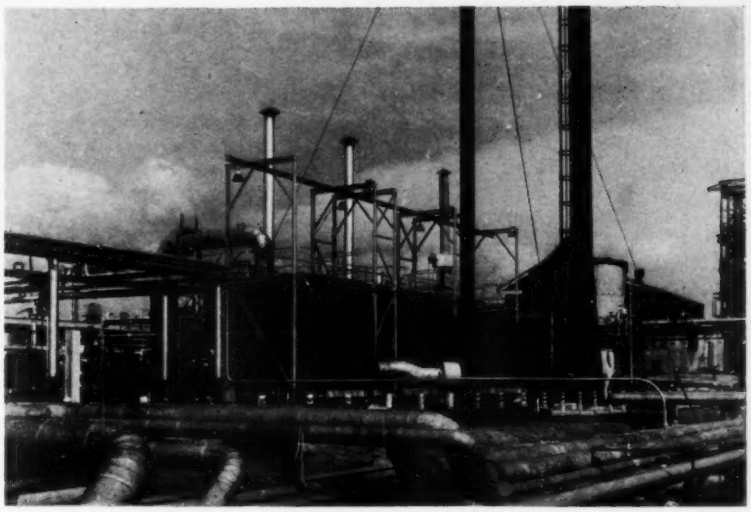
Britain's First Sulphur-from-Petroleum Plant

Ten thousand tons p.a. from refinery gases

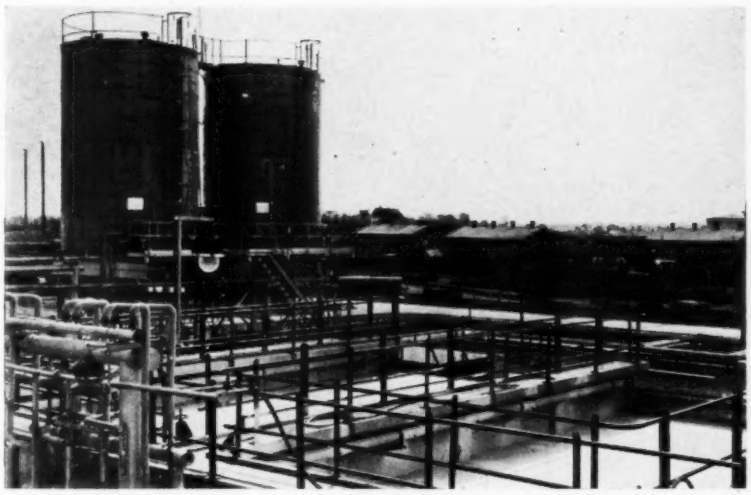
A YEAR ago the shortage of sulphur caused by the cut in American exports of brimstone to Britain was causing anxiety to industry generally and to the chemical industry in particular. Today, the feeling of crisis has passed and sulphur and sulphuric acid are not so acutely scarce. This is not due to an increase in American exports but rather to the steps taken by British firms to ease the situation. Sulphuric acid needs have been pruned by economy measures taken in many factories. This reduction in demand has also, unfortunately, been due to the temporary depression in the textile industries. On the output side there has been a gradual increase in capacity for producing acid from pyrites. But the outstanding development in production has been the erection of a plant for producing very pure rock sulphur from the waste gases of petroleum refining by the Shell Co. at their huge Stanlow (Cheshire) refinery.

This plant, which we recently saw in operation, is the first of its kind in Britain. It is capable of producing 10,000 tons p.a. of rock sulphur of 99.9% purity and it was built within a year, coming into production last March.

The plant is a compactly engineered unit with a high degree of automatic control. The basic principle of its operation is that when hydrogen sulphide is burned in a controlled quantity of oxygen, pure sulphur results from the combustion.



A general view of the sulphur plant.



The sulphur boxes in which the liquid sulphur is pumped and where it solidifies to rock hardness. It is then broken up with pick and shovel for delivery.

Manufacturing process

The raw material for the sulphur plant is the mixture of H_2S and other gases produced by the new catalytic cracker in the manufacture of motor spirit. The H_2S is led into an extraction column where it is stripped from the other gases by means of diethanolamine, a solvent for H_2S. The mixture of hydrogen sulphide and solvent is separated into its two components in a solvent recovery plant. The solvent is recycled to the extraction column while the pure H_2S goes to the sulphur plant through a pipe which is distinguished from the maze of other pipes in the refinery by its colour, appropriately yellow.

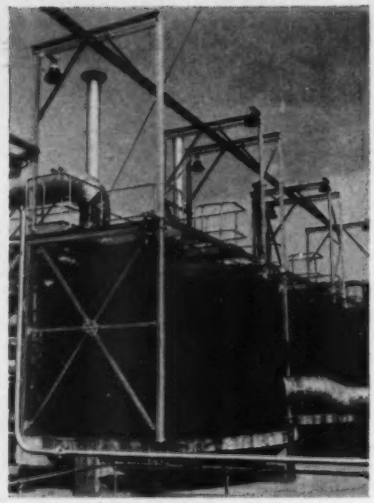
At the plant the H_2S is picked up by two sets of powerful blowers which pass it, together with air, into a Claus kiln where it is burned over a catalyst bed. This pass results in the extraction of about 50% of the sulphur which is drawn off as a liquid. From a strictly economic standpoint, 50% recovery is sufficient, but as it is impossible to discharge the residual gas to the atmosphere without further cleaning, it is passed through another Claus kiln which progressively cleans the gas and, in the process, extracts more sulphur In the last stage, any residual H_2S is passed through a line burner into a third kiln containing catalyst, where it is converted to SO_2 before going to the atmosphere. The result of this processing is the extraction of 97% of the sulphur present in the original gas entering the plant.

The sulphur is drawn off at each stage in the form of a liquid and passed through steam-jacketed pipes to large sulphur boxes where it solidifies as a bright yellow product waiting to be broken up, and loaded for delivery as required. If desired, it can be delivered as a liquid.

A large amount of heat is produced in the Claus kilns and this is charged with steam into a waste heat boiler, superheated, and used in the plant.

Sulphuric acid plant

In the refinery and the chemical plant at Stanlow a large amount of sulphuric acid is used in various processes. Therefore, about 5,000 tons p.a. of the sulphur produced in the new plant will be used by Shell themselves. To this end, a sulphuric acid plant is being built. Taken with the existing regenerators for concentrating weak process acid, these measures will



A close-up of the Claus kilns in which hydrogen sulphide is reacted with air over a catalyst to produce sulphur.

result in Stanlow producing enough sulphuric acid for its present needs.

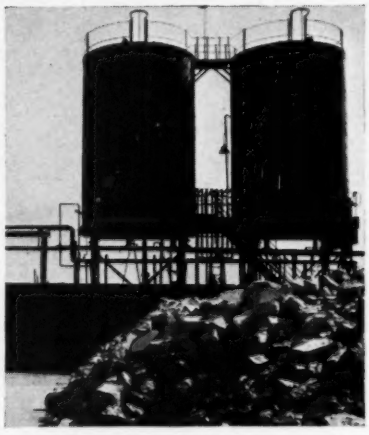
Development of Stanlow

The building and operation of the sulphur plant marks another stage in the development of Stanlow as the most versatile petroleum processing complex in the country. Since the war £30,000,000 have been spent on building new facilities there.

From the feedstocks, which are discharged at the Stanlow lay-byes at the rate of about 12,000 tons/day, are produced almost every conceivable kind of petroleum product, from bitumen to lubricating oils and aviation spirit, besides many chemicals and, of course, the famous detergent, *Teepol*. The unique chemical plant produces tens of thousands of tons annually of acetone, isopropyl alcohol, diacetone alcohol, methyl ethyl ketone, methyl isobutyl ketone and other solvents.

The Stanlow site, originally developed in 1922 by Shell for the discharge and storage of oil from overseas, has now grown in area to no less than 1,660 acres, of which more than half is occupied by refinery facilities and buildings. There are about 18 miles of major roads, 10 miles of rail track and about 500 miles of pipelines. It boasts the largest cooling tower in Europe, a vast concrete structure that rears 340 ft. into the air with a diameter at the base of 270 ft.

Apart from construction workers, about 5,000 people are permanently employed at Stanlow, some 850 of which are connected with the research laboratories. In size and versatility Stanlow can certainly lay claim to being one of the world's very biggest specialised refineries.



Pure rock sulphur, broken up ready for delivery, photographed at the plant.

Book Reviews

Industrial solvents

This book* is described as the most comprehensive reference book on industrial solvents. Whilst I have probably not read all the books there are on solvents, I should say that this statement is substantially correct. Starting with the index, I looked up a number of names and found them all mentioned somewhere. It appeared, for example, that the American 'isooctanol' was missing, but on checking the text a brief mention was found. More information might have been given, since this alcohol has been available now for some years. Speaking of the book as a whole, however, the data it provides on 380 or more solvents maintain the author's claim to comprehensiveness. Since the range of solvents is now so great, descriptions of plasticisers have been omitted.

The first chapters deal with the theories of solution, well illustrated by practical examples and leading to a description of general characteristics usually looked for in the case of nitrocellulose solvents. The section on industrial applications covers a wide field from lacquers to brake fluids and from vegetable oil extraction to DDT sprays. This is not, however, a book which can be easily read for general information. The large number of tables and graphs included do not make reading easy but this is inevitable in a reference book.

There is a new chapter on the safe handling of solvents which, naturally, deals with the matter from the viewpoint of American regulations and test methods, which may differ from British practice.

More than half the book deals with the characteristics and properties of individual solvents, grouped under chemical headings as is usual. Here again it should be remembered that the book is American and that British specifications for chemicals may differ in some respects. For instance, commercial diacetone alcohol is described as containing up to 15% acetone; in Great Britain, acetone-free material is sold industrially.

Mellan is an excellent reference book containing a mass of authentic information for both makers and users of solvents.

W. E. CASH,
M.Sc., M.I.CHEM.E., F.R.I.C.

**Industrial Solvents*, by Ibert Mellan. Second edition. Chapman & Hall, 1951. Pp. 758 including index, 96s.

Safety in factories

This book* has been designed for the use of factory managers, and all others concerned with management, safety and welfare of workers, to enable them to check their responsibilities under the Factories Acts and the Regulations made under them. It fills a long-felt want and its use will enable anyone to find a quick answer to any problem they may have concerning factory safety legislation.

The compilers are to be congratulated on producing within 90 pages a complete guide to the principal safety requirements of the Factories Acts, 1937 and 1948. The guide has been classified under 15 sections, and all items in these sections have been indexed and cross-indexed in what must be the only full index to some of the complexities of the Factories Acts and the many Statutory Instruments which are legal requirements under these Acts.

The guide does not in any way pretend to be a legal guide; no attempt is made to interpret the requirements or to give advice on fulfilling them. It gives quite clearly and precisely the facts—that is, definitions, direct requirements, exceptions and exemptions—and lists under each section the full title and number of the Statutory Instruments concerned. Each page has marginal reference to the sections and sub-sections of the Acts involved, the numbers of the legal forms to be used and the Statutory Instrument related to the context of the paragraph.

**A Guide to the Principal Safety Requirements of the Factories Acts, 1937 and 1948.* Royal Society for the Prevention of Accidents, 1951. Pp. 90, 15s. net.

Automatic Control

(*Concluded from page 364*)

to the British Instrument Industries' Exhibition, held in 1951 at Olympia, London, could well appreciate and, given adequate production and development facilities, it should be able to provide the process industries with all the support needed in the provision of suitable instrumentation.

REFERENCES

[1] Z. G. Ziegler and N. B. Nicholls: *Trans. A.S.M.E.*, 942, **64**, p. 759.
[2] G. H. Farrington: 'Fundamentals of Automatic Control,' Chapman & Hall, London, 1951.
[3] C. I. Rutherford: *Proc. I. Mech. E.*, 1950, **162**, p. 334.
[4] A. R. Aikman: *Trans. Soc. Inst. Tech.*, 1951, **3**, p. 2.
[5] *Idem: Inst. Practice*, 1951, **5**, p. 393.
[6] H. E. Hallikainen and D. J. Pompeo: *Instruments*, 1952, **25**, p. 335.
[7] A. J. Young: *Industrial Chemist*, 1951, **27**, p. 195.

CRYSTALLISATION

Crystal growth; ammonium sulphate; sugars; high polymers; production processes

By A. W. Bamforth
(Power-Gas Corporation Ltd.)

Crystal growth

WITH all crystallisable salts, supersaturation of the mother liquor can be released either as growth on existing crystals, or in the formation of new nuclei. The de-supersaturation of a supersaturated solution in either case varies considerably from one material to another, and can be more or less modified by external factors such as temperature, impurities and agitation. There is an optimum growth rate for each crystallisable substance and if that optimum is exceeded with the result that the remaining supersaturation of the solution is high, new nuclei will be formed.

Although chemical manufacturers are not normally interested in large crystals as such, since in some cases small crystals are less likely to be contaminated with occluded mother liquor, there is nevertheless a demand for large crystals, which may be based upon production economies as in the case of copper sulphate; suitability for some specific purpose as in the case of fishery salt or chemical fertilisers; or merely upon tradition as in the case of sodium thiosulphate.

When the rate of de-supersaturation of a supersaturated solution is sufficiently slow for crystal growth to be distributed throughout a crystal suspension, the known methods for continuous crystallisation are satisfactory. When, however, it is desired to produce smooth large crystals at high production rates, of substances such as ammonium nitrate or calcium nitrate which are characterised by rapid growth, it is essential that the supersaturation of the mother liquor be released uniformly upon all crystal neuclei present.

Even distribution is not completely possible in the normal types of crystalliser and this problem becomes more pronounced as the size of the crystallising vessel increases. Because of rapid crystal growth, only those crystals in the immediate vicinity of the point of introduction of supersaturated solution grow and all available solute is deposited upon crystals in this area. In large crystallising vessels a channelling effect may occur and the supersaturated liquor following the line of least resistance flows through the less densely populated zones of the crystal suspension.

A patent by Saeman[1] for overcoming the above difficulties, and providing for the production of strong, smooth coarse crystals of materials having rapid growth characteristics, comprises a method of distributing the supersaturated solution in two zones; a lower crystallising zone where the mother liquor is maintained in a streamlined vertical rotation and an upper relatively quiescent zone where fine crystals produced by attrition in the lower zone can be grown to a larger size. The grown crystals are then introduced into the lower zone as seed crystals.

A patent application[2] proposes the use of various shaped baffles in the crystallising zone to prevent by-passing of supersaturated mother liquor through a crystal suspension.

Chatterjee[3] has studied the effect of different rates of stirring upon the crystallisation of copper sulphate. The product obtained at low speeds was agglomerates of fines; at 145 r.p.m., however, shiny, free flowing crystals of medium size were obtained which are said to be suitable for bulk storage. This worker has produced a series of temperature-concentration curves showing the change of concentration in the crystalliser during crystallisation. These curves indicate that as the rate of stirring increases, the degree of remaining supersaturation of the mother liquor decreases.

Yamanoto[4] has investigated the supersolubility of ammonium sulphate in pure solutions, and has ascertained that for the temperature range 20-43°C., the solubility can be 4-5% higher than for normal values.

The dendritic crystallisation of a large number of inorganic salts from aqueous solutions in the presence of gelatin or agar-agar has been studied by Til'mans.[5] The tendency towards dendrite growth is increased by the additions. Til'mans proposes that dendrites are formed as the result of predominant growth of corners and are favoured by a limited supply of feed solution. Additions of iron, cobalt or nickel chlorides to salts crystallising in the form of dendrites suppresses the dendrisation.

The rapid crystallisation of calcium gluconate is essential to prevent fermentation and moulding. The rates were studied by Balasundaram and Subrahmanyan[6] over the temperature range 10-15°C. Maximum rates were observed at 37°C. when approximately 20 min. was required to reduce a 20% supersaturated solution to its saturation value.

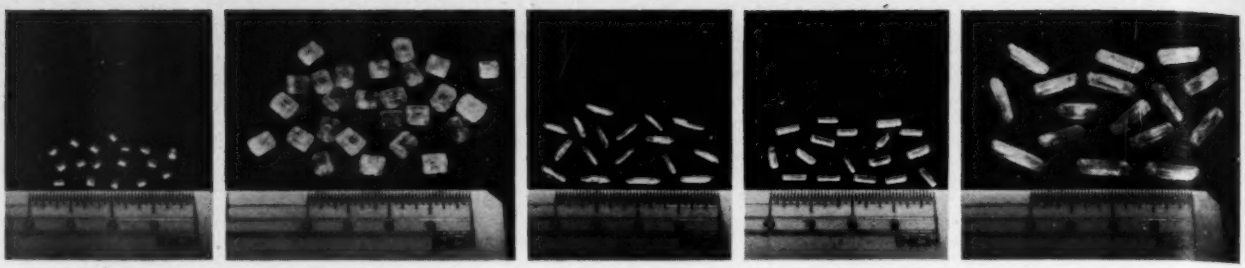
Other reports of studies of crystal growth and habit include those on the crystallisation of polyurethan;[7] the crystallisation of silver nitrate in a magnetic field[8] and the crystallisation of solutions of potassium and strontium nitrates with the use of radioactive strontium as an indicator.[9] Strongly supercooled liquid phosphorous crystallises at higher linear velocities than any reported for any other substances.[10] A study of the dielectric properties of water of crystallisation has been made by Kamiyoshi and Miyamoto[11] and dielectric constants determined for a number of common inorganic salts. It was found that the additivity law of molar polarisation held between the water of crystallisation and the remainder of the compound.

The dielectric constant of water of crystallisation was 3.75, which is nearly the same as that of ice but not that of water. As the temperature approaches the one at which the water of crystallisation is released, the dielectric constant of the water of crystallisation becomes greater. This transformation begins at fairly low temperatures. The temperature coefficient of the dielectric constants of the anhydrous compounds were all positive.

The influence of temperature upon the absorption of microwaves by water of crystallisation and absorbed water has been reported.[12]

Grove and Gray[13] summarise work published during 1949 to 1951 on theories of crystal growth, solubility and phase equilibria, the technique of growing larger single crystals and improvements in various industrial crystallisation processes.

Svanoe[14] describes the metastable and labile zone of supersaturation, types of temperature/solubility curves and the application of industrial crystallisers to the



a *b* *c* *d* *e*

Ammonium sulphate crystals as produced in a 'Krystal' evaporator, indicating the variation in shape which is possible by the addition of iron, alum, etc.; and the range of size of crystals which can be uniformly produced by simple adjustment of operating conditions.

(*a*) *and* (*b*) Orthorhombic crystals of synthetic ammonium sulphate produced by evaporation of concentrated solution at 80° C. Solution free of iron and aluminium.

(c) Hexagonal crystals of synthetic ammonium sulphate produced by evaporation of concentrated solutions at 80° C. containing ferric ions. Within limits the length/breadth ratio increases as the amount of ferric ion increases.

(*d*) *and* (*e*) Hexagonal crystals of synthetic ammonium sulphate produced by evaporation of concentrated solution at 80° C. containing aluminium sulphate and sulphuric acid. The optimum conditions to produce 'rice' crystals of 1 to 3 or 4 length/breadth ratio is 0.2 g. H_2SO_4/100 ml. and 0.8 g. Al_2O_3/100 ml. of solution. The difference in size of crystals between (*a*) and (*b*) and (*d*) and (*e*) is produced by varying the rate of circulation in the evaporation.

crystallisation of organic compounds from solution.

Ammonium sulphate

On March 2, 1952, the Prime Minister of India officially opened his Government's fertiliser factory at Sindri, Bihar, India, which was put into operation last autumn and which will be producing at the rate of 1,000 tons/day of ammonium sulphate in the near future.[15] The Power-Gas Corporation Ltd., who were the contractors for this vast project, have recently published an illustrated brochure covering all sections of the factory.[16]

In Portugal, a smaller but nevertheless substantial scheme is in hand and this country hopes to be producing an additional 50,000 tons of ammonium sulphate p.a. and so become self-supporting in this commodity by the end of the year.[17]

In the research field ammonium sulphate likewise holds interest generally in connection with the study of crystal habit and on means to overcome the caking tendency of this fertiliser in storage. The now normal 'rice' crystal of synthetic ammonium sulphate is a modification which has developed in an endeavour, on one hand, to overcome the caking tendency of 'sugar' crystals, and the fragility of the by-product sulphate needle crystals, on the other.

Ettle[18] describes the effect of various impurities and of the method of crystallisation on the crystal habit. The effect of additions of sulphuric acid, iron alum, chromium and phosphate were studied. The presence of phosphate was found to completely inhibit the formation of rice crystals. On the other hand, the trivalent irons of iron, chromium and aluminium appear to have the most pronounced effect. It is possible that their influence is associated with their readiness to form alums. Optimum conditions are 0.2 g. of sulphuric acid and 0.08-0.12 g. of aluminium oxide per 100 ml. of solution. In the absence of aluminium the common alkali metals appear to have no effect although within limits calcium sulphate improves the shape and size of the crystals. The use of oxalic acid, sodium thiosulphate and the magnesium salts to suppress the growth tendency of the crystals in only one direction is also studied.

Rabkin and co-workers[19] have studied the effect of acidity and impurities on ammonium sulphate obtained from the direct reaction of ammonia with sulphuric acid. The optimum-free sulphuric acid concentration for the production of large-size sulphate crystals was found to be 9-15 g./l. This optimum value appears to be constant whether the impurities introduced into solution from coke-oven gas are present or not, but the impurities tend to reduce the crystal size below those obtainable from pure solutions. The presence of chloride in particular retards crystal growth.

A patented method[20] of lowering the tendency towards setting of ammonium sulphate is by the distribution of a sulphurated aromatic dye over the crystal surface by evaporation from aqueous solution. The ammonium sulphate crystals produced are in the form of thin, fragile, friable crystals.

Corrosion problems which are encountered in plant-handling ammonium sulphate liquors are probably as severe as any met with in industrial practice. Very little reliable corrosion data has been published. Stainless steels, of course, are largely used, but possibly the presence of trace elements as impurities in sulphate liquors and the fact that stainless steels having the same analysis from different makers differ marginally on corrosion resistance, can make the use of stainless steel a hazard, unless exhaustive tests are carried out on the steel with the actual liquor with which it is proposed to work. Some aspects of the problems associated with the maintenance of ammonium sulphate plant are discussed by Alkashi.[21]

Sugars

A crystalliser for sugar solutions has been patented in the U.S.[22]

Valeri[23] makes calculations by Kucharenko's formula on data from Grutt and others for determining the time required for crystallisation in various types of sugar boiling and in mixers.

The heats of crystallisation of sucrose from aqueous solutions at 30° and 57° have been determined.[24] The values obtained show large discrepancies as compared with corresponding values calculated from data obtained by other observers. The differences are explained as being due to the inadequate data available for the necessary corrections.

The rate of crystallisation of unstirred sugar solutions of 1.1 supersaturation without seeding and 1.2 supersaturation with auto-nucleation at 40°C. is examined by Misra and Mukherji.[25] The amounts and sizes of added crystals do not affect the rate of crystallisation. The observed rate of crystallisation is much lower than in published work with stirred solutions. The relation between time of crystallisation and the amount of sugar crystallised is examined by Golovkov[26] and the size distribution of sugar crystals is examined by van Hook.[27] The size distribution follows the arithmetical probability curve and is linear between 2% and 90% values. This suggests a heterogeneous mechanism of nucleation in normal boiling and a critical dependance of nucleation upon supersaturation when impurities are excluded.

The methods of boiling low-grade sugars and the subsequent treatment in the crystallisers at Tirlemont, Belgium, are described and discussed;[28] another review[29] covers the processing methods and practice in Polish factories.

Crystallisation of high polymers

A brief description of the main structural differences between polymeric and ordinary materials followed by a discussion of the

thermodynamics of crystallisation, the change of melting point with the temperature of crystallisation, crystallisation under stress, etc., is given by Kapur.[36]

The isothermal crystallisation of high polymers has been investigated[31] and the change in crystallisation velocity noted. The isothermic crystallisation curve is S-shaped as in the case of rubber.

A critical review and discussion of methods available for the determination of crystallinity in high polymers has been published.[32] The treatment of cellulose with HCl and $FeCl_3$ which hydrolyses the cellulose and then oxidises the glucose to CO_2 gives higher degrees of crystallinity than do the non-destructive methods of determination such as X-ray diffraction and isotope exchange. This may be due to an additional crystallisation induced by the reaction. The phenomenon can be used in the separation of cellulose from lignin, and in the explanation of fatigue in fibres. Heats of crystallisation of cellulose can be determined by treatment of amorphous cellulose with hot water, and then determining the degree of crystallinity by a non-destructive method.

Production processes

The production of ammonium sulphate by the sulphurous acid method is patented by Miyama[33] and from gases having a low sulphur dioxide content by Grosskinsky and co-workers.[34] In the latter patent ammonium sulphate is prepared by scrubbing gases containing less than 1 vol.% sulphur dioxide with an aqueous solution into which ammonia is introduced. Temperature of the scrubbing liquor, the *p*H and space velocity in the scrubber require strict control. Examples given state that scrubbing a gas containing 1% SO_2 at given conditions shows a loss of 0.17% SO_2 and 0.11% NH_3 in the exit gas, the percentages being based upon the total charge; a gas containing 0.1% SO_2 scrubbed as described gives a waste gas corresponding to a SO_2 loss of 2.2% and a NH_3 loss of 0.69%.

The control of the exothermic reaction temperature of NH_3 and H_2SO_4 in a spray type reactor by the addition of a coolant is also patented.[35]

Crystalline diammonium phosphate of high purity is produced continuously by passing anhydrous ammonia and relatively pure phosphoric acid into saturated diammonium phosphate liquor.[36] The process is carried out first in a saturator of the ammonia phosphate type, then in a vacuum crystalliser. The heat of reaction provides the necessary heat for evaporation of excess water.

Calcium hypophosphite crystals are prepared from yellow phosphorus, $CHCl_3$ and lime in a special closed reactor.[37] After the digesting period the upper limpid part of the mass which is formed is saturated with CO_2, altered, concentrated in vacua, and allowed to crystallise. Phosphine which is evolved is absorbed.

Laboratory and industrial crystallising techniques are described in two books.[38, 39]

The operation of the Holland evaporator designed for the production of anhydrous sodium sulphate from Glauber's salt is described.[40] This evaporator dehydrates the material in a space where there are not hot surfaces to which scale can adhere. Four units of this plant producing a total of 400 tons/day of anhydrous sodium sulphate are operating in Saskatchewan.

REFERENCES

[1]W. C. Saeman (to the U.S.A. as represented by the Tennessee Valley Authority), U.S. Pat. 2,567,968, September 18, 1951.
[2]G. Milner, A. W. Bamforth and the Power-Gas Corpn. Ltd., Brit. Pat. 9558/50, April 19, 1950.
[3]G. S. Chatterjee (Coll. Eng. & Technol., Jadapur), *Trans. India Inst. Chem. Engrs.*, 1948-49, **2**, p. 57-62.
[4]T. Yamanoto (Cent. Meter. Observatory, Tokyo), *J. Chem. Soc. Japan, Pure Chem. Sect.*, 1950, **71**, pp. 114-115.
[5]Gu. Ga. Til'mans (Techn. Inst. Chimkent. S. Kazakh S.S.R.), *Doklady Akd. Nauk. S.S.S.R.*, 1951, **78**, pp. 83-86.
[6]S. Balasundaram and V. Subrahmanyan (Indian Inst. Sci., Bangalore), *J. Sci. Ind. Research*, 1950, **10B**, p. 121.
[7]E. Jenckel and E. Klein (Techn. Hochschule, Aachen), *Kolloid Z.*, 1950, **118**, pp. 96-103.
[8]G. Mayr, *Rend. Ist. Lombardo Sci.*, 1949, **82**, pp. 406-412.
[9]J. Pauly and P. Sue, *Compt. Rend.*, 1950, **231**, pp. 1479-1480.
[10]R. E. Powell, T. S. Gilman and J. H. Hildebrand (Univ. of California, Berkeley), *J. Am. Chem. Soc.*, 1951, **73**, pp. 2525-2526.
[11]K. Kamiyoshi and T. Miyamoto, *Science Rpts. Research Insts.*, Tôhoku Imp. Univ., 1950, **2**, pp. 370-379.
[12]M. Freyman and R. Freyman, *Compt. Rend.*, 1951, **232**, pp. 1096-1098.
[13]C. S. Grove, Jun., and J. B. Gray, *Ind. Eng. Chem.*, 1950, **42**, pp. 28-31.
[14]H. Svanoe (Struthers Wells Corpn.), *J. Chem. Education*, 1950, **27**, pp. 549-553.
[15]CHEMICAL AND PROCESS ENGINEERING, 1952, **33** (5), pp. 247-253.
[16]The Power-Gas Corpn., S.F.F. 252.
[17]*Chem. Trade J.*, 1950, **12**, p. 926.
[18]G. W. Ettle, Proc. Fertiliser Soc., 1949, No. 5, pp. 47-63.
[19]M. A. Rabkin, A. P. Romanenko and M. E. Kovalskaya, *J. Appl. Chem. U.S.S.R.*, 1951, **24**, pp. 1257-1262.
[20]A. Butchart, J. Whetstone and I.C.I. Ltd., Brit. Pat. 649,240, January 24, 1951.
[21]H. Alkashi and Kagaku No Ryôiki, *J. Japan Chem.*, 1948, **2**, pp. 212-217.
[22]I. Merlis (Acme Coppersmithing & Machine Corpn.), U.S. Pat. 2,504,033, April 11, 1950.
[23]G. M. Valeri, *Ind. Saccar. Ital.*, 1950, **43**, pp. 261-276.
[24]E. J. Kilmartin and A. van Hook, *Sugar*, 1950, **45**, p. 34.
[25]B. K. Misra and B. K. Mukherji, *Trans. Indian Inst. Chem. Eng.*, 1948-49, **2**, pp. 50-56.
[26]P. D. Golovkov, *Sakhar. Prom.*, 1951, **2**, pp. 18-21.
[27]A. van Hook, *Proc. Amer. Soc. Sug. Beet. Technol.*, 1950, pp. 570-576.
[28]J. Storme, *Sucr. Belge*, 1950-51, **70**, pp. 261-274.
[29]S. Gawrych, *Gaz. Cukr.*, 1951, **53**, pp. 4-8.
[30]S. L. Kapur (Natl. Chem. Lab., Poona), *Paint Manufacture*, 1951, **21**, pp. 5-8.
[31]Anon., *Chem. High Polymers* (Japan), 1950, **7**.
[32]R. Britt and H. Mark (Polytechn. Inst., Brooklyn), *Z. Electrochem.*, 1951, **55**, pp. 202-207.
[33]T. Miyama, Jap. Pat. 178,762, April 30, 1949.
[34]Bergwerksverband zur Verwertung von Schutzrechten der Kohlentechnik GmbH., assignee of O. Grosskinsky, W. Kempt. and A. Adelsberger, German Pat. 801,837, January 25, 1951.
[35]H. D. Chapman, W. I. Denton and R. B. Bishop (to Socony-Vacuum Oil Co. Inc.), U.S. Pat. 2,524,341; October 3, 1950.
[36]H. L. Thompson, P. Miller, R. M. Johnson, I. W. McCamy and G. Hoffmeister, Jun. (T.V.A.), *Ind. Eng. Chem.*, 1950, **42**, pp. 2176-2182.
[37]G. Pettazzi, Ital. Pat. 456,918, April 29, 1950.
[38]H. E. Buckley, 'Crystal Growth,' Wiley, New York, 1951.
[39]A. Weisberger, 'Technique of Organic Chemistry,' Vol. III, Chap. VI, Interscience, New York, 1950.
[40]A. A. Holland, *Chem. Eng.*, 1951, **58**, p. 106.

New standards

Distillation apparatus. First published in 1936 under the title 'Distillation apparatus,' (B.S. 658:1952) apparatus for the determination of distillation has now been completely revised and brought up to date. It specifies the components of apparatus suitable for a wide range of standard distillation range tests, including many of industrial importance. It includes two types of draught screen and three types of condenser, and permits either a gas burner or an electric heater to be used. An appendix describes the correction of barometric readings to standard temperature and pressure, which enables the distillation temperatures recorded to be corrected as laid down in the specification for the particular liquid concerned.

It has not been found possible to specify a simple apparatus to meet the requirements of all distillations, especially where standard methods are concerned which have been specified precisely for many years and cannot be varied without exhaustive tests to ensure that comparable results will still be obtained. But it is anticipated that the apparatus described will be fully adequate for many standard tests and, where minor variations in apparatus still remain, these may probably be ignored in routine work, although for referee purposes the particular specification in question should, of course, be followed rigorously. The standard costs 2s. 6d., post free.

Bitumen road emulsion. The British Standard for bitumen road emulsion for penetration (grouting and semi-grouting) and surface dressing (B.S. 434:1952) has been revised and covers composition of emulsion, requirements for the bitumen used in its manufacture, proportion of emulsifying agent, sampling of emulsion for testing, water content, residue on sieving, storage stability, coagulation of emulsion at low temperature, viscosity of emulsion, and sedimentation. The various methods of testing are described in appendices. The standard costs 4s., post free.

The above standards can be obtained from the British Standards Institution, London.

VACUUM TECHNIQUE

Constructional materials for vacuum systems; evaporation; cooling; dehydration; crystallisation

By S. L. Martin, M.Sc., A.R.C.S., D.I.C., F.R.I.C.

IN this review recent publications dealing with high-vacuum technique and applications are summarised. Information relevant to the sources of gas in vacuum systems additional to that given in the last review[1] is discussed. The applications to evaporation and crystallisation on a large scale are treated in more detail.

The symposium on vacuum physics organised by the Midland Branch of the Institute of Physics at Birmingham in June 1950 has now been published.[2] This booklet contains 11 papers, covering means of creating and maintaining vacua (pumps and system design), vacuum gauges and methods of leak detection (three papers) and five papers on various types of application—dehydration, freeze-drying, evaporation of metals as coatings, melting and sintering metals, and the construction of the Birmingham proton synchrotron. The volume provides a source of up-to-date information and references for those interested in vacuum apparatus and plant. (Some of the material has already been reviewed in earlier reports of this series and it is intended at a later date to review in detail vacuum gauges and leak detectors; therefore, only such new information as is relevant to previous reviews will be included in the present one.) A new book by Davy[3] deals with the elements of vacuum practice and in particular with the deposition of thin films by vacuum evaporation; in thus specialising the author robs the book of much of its value as a general reference book. Magner[4] has published a small book on attaining and measuring high vacua, and two volumes by Holland-Merten have appeared as additions to his earlier one, 'Handbuch der Vakuumtechnik.' The first[5] deals specifically with applications requiring medium vacua of about 10 mm. Hg pressure, and the second[6] covers general techniques and special processes for vacuum-drying and vacuum-impregnation of electrical insulators, textiles, and so on. In a volume of the 'National Nuclear Series,' edited by Benedict and Williams,[7] information is given on mass spectrometers and new developments in vacuum engineering which resulted from applications to the gaseous diffusion process for the separation of isotopes.

Materials of construction for vacuum systems

Millen[8] points out a tendency towards the use of aluminium for vessel casings, especially where non-magnetism is a requirement, and forecasts that improvements in the manufacture of this metal will increase interest in it for this application. Malcolm[2] describes a high-vacuum melting furnace (Fig. 1), volume 50 cu. ft., fitted with three sight glasses, two pumping ports, a power feed-through and five Wilson seals for transmitting motion; stainless steel is used for the tank and internal fittings to reduce induction losses. Because of the requirements of non-magnetism, stainless steel was also considered for the vacuum box of the Birmingham proton synchrotron. According to Riddiford,[2] the vacuum requirements for this are a few orders greater than for cyclotrons and betatrons, due to the greater scattering effect of residual gas particles on the slower moving protons. Theoretical considerations demanded a vacuum box roughly 30 m. in circumference and 30 × 45 cm., in which a vacuum of the order of 10^{-6} mm. Hg could be maintained. This presented great problems, the successful solutions of which exemplify the benefits accruing to industry from stringent research requirements. Riddiford mentions that vessels were eventually made (through the co-operation of various interested firms) of chemical stoneware, 30-mm. thick, impregnated with a mixture of hot paraffin wax and beeswax, 30 sections about 1 m. long being sealed together with a specially designed seal (Fig. 3) to give a final leak-rate of only 0.03 litre-microns/sec. over a period of weeks; of sintered electrical porcelain, which was more impervious but had greater distortion on firing, and required the use of 60 sections with 60 seals; and of 35-mm. thick silica slabs cemented with a thermosetting plastic, *Araldite*. For various other reasons, attention has concentrated on the porcelain box. The final box is coated on the inside first with a conducting glaze, then with a chemically deposited platinum film, and is pumped by five manifolds (each of 600-l. volume) connected to sixty 4-in. side-arms on the box through seam-welded stainless steel bellows, each manifold connecting

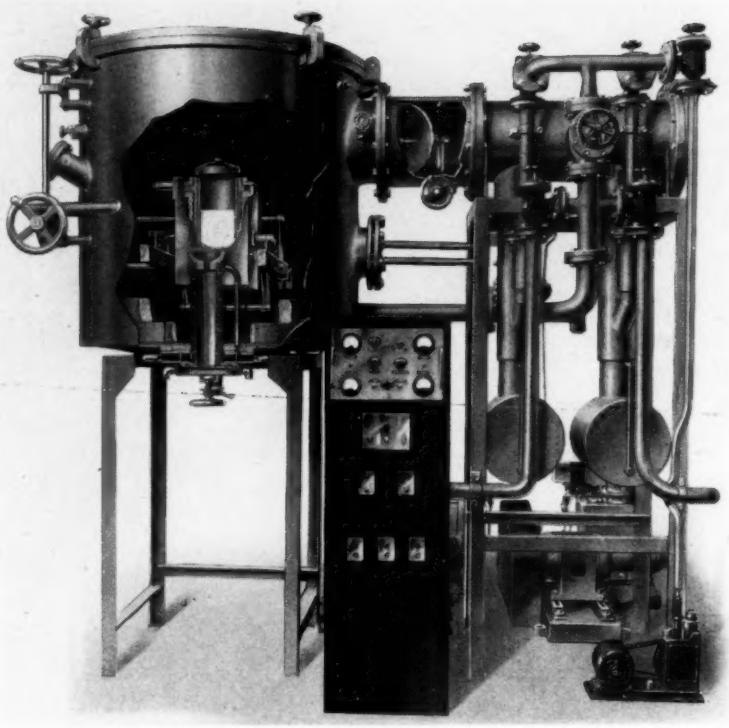


Fig. 1. High-vacuum melting furnace.

to a 16-in. diffusion pump backed by a rotary pump. There are eight ionisation gauges suitably disposed around the box. It is possible to attain and maintain the desired vacuum with this box (Fig. 2), which has 500 vacuum seals altogether. Millen suggests that for certain applications polythene tubing (welded) may present economic advantages over copper or steel for smaller pipelines.

Fig. 3 shows the sealing arrangement used on the synchrotron to seal the porcelain sections—the most difficult. It consists of four $\frac{3}{16} \times \frac{3}{16}$ in. soft rubbers bonded two on each side of a metal plate for mechanical strength, the spring contacts shielding the rubbers from the proton beam. The seals are clamped in partly before evacuation, after which the pressure differential ensures tightness. Flanges and unions with rubber gaskets (all double ones to improve leak detection) are used for other joints. Holland[2] also mentions that on the latest vacuum-evaporation plants demountable flanges and unions with 'O' ring-seals of synthetic rubber are now used.

Hintenberger[6] has described some experiments with metal foils as sealing gaskets. For certain applications, particularly where high temperatures may be encountered, these have advantages over rubber. There have been many instances of the use of metal seals over the past ten years, but the relative advantages have not previously been discussed. Examples used are aluminium and lead flanges, lead, zinc, silver, copper and gold wire rings; and silver, gold and aluminium foil. Hintenberger found that in general silver was best as a foil, but suffered from the disadvantages that it could only be used once and was expensive. He reports a method of using aluminium foil which is stated to have given excellent results for many purposes, particularly on a mass spectrograph where with three such seals operating at 280 to 320°C. good vacuum performance was obtained over eight months during which the seals were opened many times; rubber seals gave much worse results. Brass or Monel metal flanges are used, each pair being accurately dimensioned and carrying well-fitting bolts. The top flange has a 'V'-shaped circular projection which fits into a similar but slightly smaller depression in the lower flange. The foil is circular, is stamped from sheet 0.2 to 0.3 mm. thick, and is pre-grooved to about three-quarters of the final depth of the 'V' in order to prevent creasing on bolting the flanges together—which is considered the major cause of 'untightness' of a seal. Four bolts are used for diameters up to 65 mm., and six to eight for larger sizes, in order to ensure even pressure. Copper seals are also effective, but the copper must first be treated with dilute hydrochloric acid to remove the oxide layer.

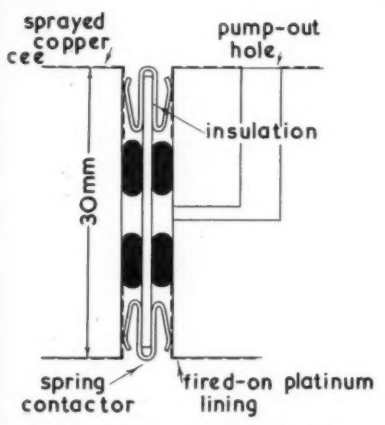


Fig. 3. Gasket for sealing porcelain sections of synchrotron vacuum chambers. It comprises four $\frac{3}{16} \times \frac{3}{16}$ in. soft rubbers, bonded two on each side of a metal plate providing the mechanical strength.

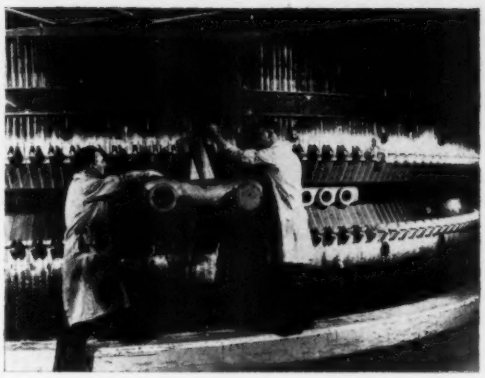


Fig. 2. Birmingham synchrotron magnet with a section of the vacuum chamber and portion of the pumping manifold in place.

Millen has issued a plea for the standardisation of the sizes of bolts, circles and gasketing methods. He has also indicated a definite tendency towards the operation of valves not manually, but by some power mechanism such as mechanical linkages from a central camshaft, electromagnetic operation of glandless valves, electric motor drives, or hydraulic and pneumatic methods for plate-type valves which seems most widely accepted for large-scale plant. This would permit control of the plant from a cental control panel.

Residual gases in vacuum systems

On the question of the nature and origin of the residual gases in vacuum systems, Blears[2] has reported some interesting results obtained with a mass spectrometer, which underline the usefulness of this instrument not only as a leak detector, but also for the study of gases evolved from various constructional materials and for analysing residual gases in a dynamic vacuum system — of which the mass spectrometer itself is a good small-scale example. Two types of instruments were used: (*a*) borosilicate glass with copper-glass seals and no gasketed joints at all, the tube being evacuated with a mercury diffusion pump; and (*b*) tubes of brass or stainless steel with rubber gaskets, and evacuation by oil diffusion pumps. Experiments were carried out with and without vapour traps. Blears' results may be summarised as follows.

Initial evacuation of *air* is rapid, the partial pressure of oxygen falling to 10^{-7} mm. Hg in 20 min. and 10^{-8} mm. in 1 hr., at which time the air constituted only 0.5% of the total residual gas (total pressure 10^{-5} mm.). The rest consisted largely of water vapour or products formed from water vapour, mercury vapour with type *a* tube, some hydrocarbons with both types (originating from pump oils with type *b* or from the *rotary* pump oil with type *a* where the tube was first evacuated with the roughing pump), and some CO and CO_2 which were shown by separate experiments to result from the attack of water vapour on the carbide layers formed on the hot tungsten filaments through decomposition of hydrocarbon vapours thereon. Continued pumping without baking reduced the water vapour gradually, whereas the pressure of hydrocarbons approached a limiting value.

After reaching constant residual pressures, the systems were baked at 100 and then at 250°C. It was found impossible to pump away the water vapour with cold traps at −78°C., whereas the hydrocarbons, with a lower vapour pressure, could be reduced. This, coupled with the first observations, provides direct evidence for the view previously widely proposed that these vapours are so tenaciously held by glass and metal surfaces that the surfaces will effectively 'back-pump' them from vapour sources such as cold traps, even though the vapour pressure at the temperature of the trap may be considerably less than the residual partial pressure of the vapour observed in the vessel being evacuated. Thus the desirability of baking at the highest feasible temperatures, especially where cold traps are not used, and of efficient trapping arrangements are again emphasised for operations requiring the highest degrees of vacua.

Concerning the ultimate residual pressures obtainable with various pumping schemes (see Table 1), water vapour was the most abundant residual with all trapped systems. The residual hydrocarbons were higher with oil diffusion pumps than with mercury ones, but the differences tended to disappear with baking and trapping. It is again noteworthy that even after several days' baking with trapped systems the vapour of the diffusion pump fluid was still present in the fine-vacuum side at pressures some 100 or higher times the vapour pressure of the fluid at the trap temperature, again due to adsorption effects.

Thus under the comparative conditions the ultimate total residual pressures are of the same order (10^{-8} mm. Hg) for types

Table I. Gas analysis at the ultimate pressure with tubes pumped by different processes (from Blears[2])

(All values in units of 10^{-9} mm. Hg, after several weeks pumping with bakings for at least 48 hr.)

Pump fluid	Mercury			*Apiezon BW*		*Apiezon C*	
Baking temperature, °C.	100	250	100	100	100	100	100
Trap temperature, °C.	−78	−78	−170	−78	20	−78	20
Hydrogen	—	—	—	3	22	4	9
Water	19	2.2	6.0	7	25	4	9
Carbon monoxide	9	0.1	1.0	1.1	—	3.1	2.5
Air	1.0	0.5	1.8	1.6	—	0.5	1.5
Carbon dioxide	1.3	0.1	1.7	0.5	12	0.9	1.8
Hydrocarbons	4	1.2	1.3	5	1,250	10	60
Mercury	205	224	15	—	—	—	—

a and *b*, if pump fluid vapours are neglected. Blears concludes that any decomposition of pump oils occurring in the pumps, for example through excessive heating, results in the formation of lower hydrocarbons containing 2 to 8 carbon atoms and having a higher volatility. The results reported by Riddiford[2] on tests with 16-in. oil diffusion pumps tend to support those of Blears—ultimates of 14 × 10^{-8} and 3.6 × 10^{-8} mm. Hg for *Apiezon C* with traps at −78 and −180°C. respectively were obtained, with evidence of decomposition to lower hydrocarbons.

Riddiford also presents new data on the vapour pressures of oil pump fluids, all an order of magnitude less than those previously quoted.[1] The following values are interpolated from plots of log *p* against 1/*T*:

Oil	*Vapour pressure in mm. Hg* × 10^{-8}	
	25°C.	75°C. (*approx.*)
Octoil S	0.2	1,000
Apiezon B	1	13,000
Silicone DC703	3	23,000

His evidence suggests that not only do all three oils tend to decompose, but that at least half the residual pressures are due to decomposition products and that the performance varies with the age of the oil in the drum. He therefore recommends that pump oil manufacturers should aim at improvements in consistency as well as in ultimate vacua obtainable.

Industrial applications

In the high-vacuum range, interest in the evaporation of thin films has continued. Originally developed for producing anti-reflection films on lenses and for forming mirror surfaces, this process is rapidly finding further applications (Holland[2]). The manufacture of large-bore oil diffusion pumps with high pumping speeds at pressures of 1 micron and less has contributed to the development of large evaporation chambers capable of being operated as continuous processes. In many cases the use of silicone pump oils ensures better properties of the film deposits, although in some cases, for example with rhodium films, there still appears to be some effect of the vapours of these oils on the deposits. It is very important that the surfaces to be coated should be thoroughly clean if good adherence is to be obtained. In modern plants facilities are provided for using ionic bombardment in a glow discharge or electron bombardment from thoria-coated cathodes for cleaning the surfaces of conductors. With large objects a major difficulty has been in the suitable arrangement of the evaporating source to give uniform coatings, therefore facilities are now provided for rotating the objects during the coating process. Fig. 4 shows a plant with a chamber 3 ft. in diam. in which mirrors can be rotated by motors operating through vacuum seals. This can also be used to metallise plastic mouldings of various shapes for decorative or electrical purposes. Other applications include the deposition of metals on rolls of plastics or of Zn or Al on rolls of condenser paper in a continuous process for which speeds of several hundred feet per minute have been reported. For such applications the design of continuous feed evaporation sources presents certain problems.

According to Malcolm, the vacuum melting apparatus shown in Fig. 1 is capable of handling 50 to 100 lb. batches of non-magnetic steels in one casting. It is useful for developmental and semi-pilot plant work on the advantages of vacuum-cast or vacuum-sintered metals and alloys.

Vacuum cooling and dehydration

Operations such as cooling refrigerant waters or mother liquors for crystallisation processes (both by evaporation of a portion of water in vacuo), vacuum evaporation and concentration of solutions, vacuum dehydration of concentrates and vacuum freeze-drying of food extracts or concentrations and biological preparations by evaporation from the frozen product, all have as common objects and problems the removal of large amounts of water vapour and entrained gases. The pumping schemes available for this purpose have been previously reviewed,[9] and the reviews by Beckett on freeze-drying[2] and Goddard on vacuum dehydration of foodstuffs[2] show no advances in this respect. Flosdorf has published a book on the freeze-drying process as applied to food products.[10] It appears generally accepted that where ultimate pressures required are not less than 1 mm. Hg as in cooling or evaporation processes, the steam ejector is the most economical pump. With a single-stage ejector employing steam at greater than atmospheric pressure, the gases and vapours are entrained by suction due to the eddies formed at the jet nozzle, and very low pressures cannot be reached. However, if required, multi-stage ejectors can be used to obtain pressure around 50 microns when the final action of the ejector stage at the lower pressures is similar to that in vapour diffusion pumps. The economics of these multi-stage ejectors must be carefully considered, as it may prove cheaper to concentrate the liquors by a single-stage ejector and then switch over to another pumping system for final dehydrations at the lower pressures. For this reason, ejectors are seldom used in freeze-drying processes—the vapour pressure of water at 0°C. is 4.6 mm., whereas at −50°C., it is 0.034 mm. Hg.

In freeze-drying processes the concentrates can be frozen either by refrigerants or, more commonly, by loss of the latent heat of evaporation of water on evaporation of a portion of the water. The sublimed or evaporated water is now generally stripped in bulk by condensing inside a

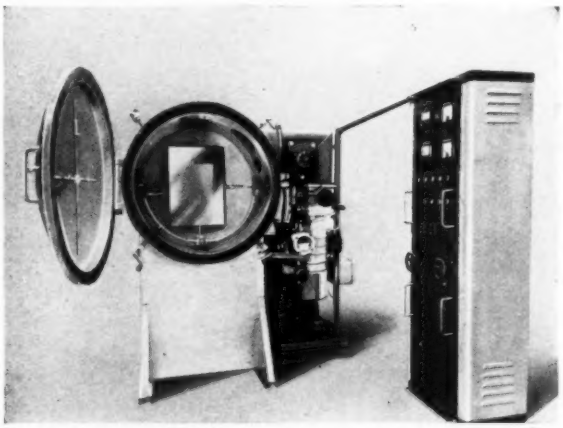


Fig. 4. Large coating plant, 3 ft. diam., for producing aluminium front surface mirrors. A mirror can be seen in position held in a frame which is rotated during evaporation.

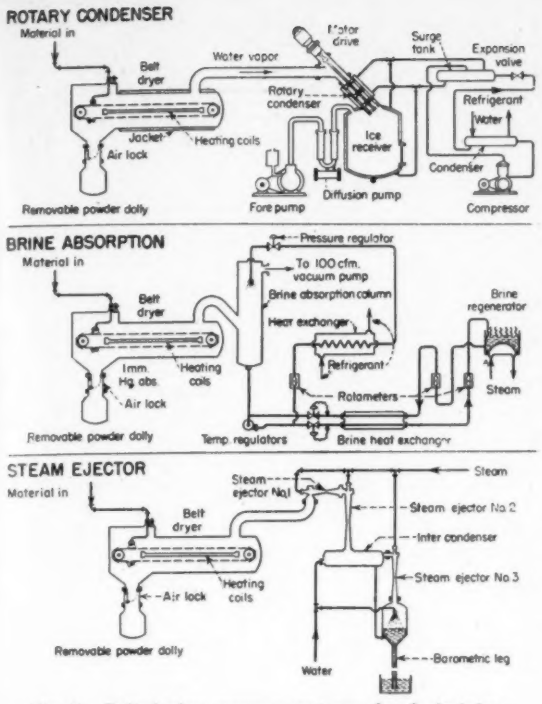


Fig. 5. Belt-drying vacuum systems for fruit juices.

tube (cooled externally by a refrigerant), from which the ice formed can be continuously scraped off by rotating blades and removed without breaking the vacuum. Beckett points out that, with this arrangement, it is of little use to employ pumps which give ultimate pressures less than the vapour pressure of ice at the refrigerated surface temperature, since then water vapour will be pumped off from the condensed ice into the pumps. Goddard[2] has reviewed the belt drying systems developed in the U.S.A. for dehydration of fruit juices. In these, the concentrate is fed through a vacuum lock on to a moving belt suitably heated in a vacuum chamber from which the water vapour is pumped (Fig. 5).[11] He states that the largest plant so far envisaged has a belt area of 400 sq. ft. and will remove 200 lb./hr. of water.

In the cellulose fibre industries, vacuum vessels have recently come into use for simultaneously sulphidising or xanthating the cellulose and mixing in one tank. Previously, sulphidisation had to be carried out in temperature-controlled rooms, the mix being left at low temperatures for some time. Niedergall[12] discusses the German vacuum-kneader, where the principle is that the mix is cooled by evaporation of the solvent. He points out that the cooling requirements of these kneaders may represent 50% of the total for the whole factory, and presents data on the temperature and rate of flow on the cooling brine solutions.

Vacuum crystallisers have been in use for some time,[13] as a natural outcome of the vacuum evaporation process originally developed for the sugar industry. The advantages of the ordinary vacuum evaporator are that it allows exhaust steam to be used for heating the liquors (lower boiling point of water under vacuum), permits the largest possible capacity per unit area of heating surface and safeguards temperature-labile materials. Optimum vacua of 50 to 100 mm. Hg (mainly water vapour) are generally used. The principle in crystallisers is that, on introduction of the warm mother liquor into an evacuated space, the adiabatic evaporation of the solvent tends to cool the solution to the temperature corresponding to the saturated vapour pressure of the solvent which the pumps are able to maintain. The crystals then separate from the cooled solution, and the process can be made continuous. Operating variables such as composition and rates of feed of liquors to the crystalliser, rates of agitation or circulation within the crystalliser, productive thermal rate and pressure are significant in continuous crystallisers.

The economics of the vacuum crystallisation process using steam ejectors have recently been reviewed by Hammer and co-workers.[14] They consider that with the newer techniques the cost of cooling by evaporation is only about half that of ammonia compression cooling, and that at −10°C. the energy relationships are better. The specific advantages mentioned are:

(1) Possibility of cooling by stages.
(2) No heat exchange surfaces required, hence no heat resistance problems.
(3) Increase of crystal yield through concentration by evaporation.
(4) Possible use of an airtight process for solutions susceptible to attack in air.
(5) Favourable use of exhaust steam at 1 to 3 atm. pressure.
(6) Simple design, small constructional costs, and simple servicing requirements.
(7) Small basic surface of plant.
(8) The coldness can be 'won back' through use as a condensing medium.
(9) The compression drop across the ejector can be lessened by use of trickle condenser.

The disadvantages mentioned are:

(1) Greater water consumption, since the ejector steam must be condensed.
(2) Height of structure.

The heat to be removed from a solution to obtain crystallisation depends on the specific heat of the solution, the mass of crystals separating, the heat of crystallisation and the heat introduced from the surroundings. It is possible to calculate the heat per kg. of solution to be removed to cool the solution; for example, for cooling saturated sodium sulphate solution from 25 to 10°C. this is about 30 k.cal. and to −10°C. about 50 k.cal./kg. solution. From this the amount of water vapour to be carried off per kg. solution can be obtained using the value for the latent heat of evaporation. This can then be related to the optimum pressures in the evaporating and condensing chambers, and to the steam pressure in the ejector.

In the process actually described, the hot solution is successively passed into a number of evaporators connected in series, the cooled solution flowing out continuously from the last. Attached to each evaporator there is a vapour compressor which compresses the evaporated water vapour into a common pipeline leading to a trickle condenser through which the whole plant is pumped by a steam ejector backed by a rotary pump. Experiments show that, with such a multi-stage arrangement, the steam consumption in the ejector decreases markedly—with 12 stages cooling saturated sodium sulphate solution from 25 to 0°C. with condenser cooling water at 25°C. the steam consumption is only 40% of that for a single-stage process. With a 12-stage process, the steam consumption for the removal of 10^6 k.cal of heat under similar conditions (cooling 25 to 0°C.) is only about 45% of that with a single stage, and only about 65% of that with vacuum cooling using ammonia refrigerants. The energy costs (vapour, electricity and water supplies) for this same cooling are about 9 and 14 D.M. per 10^6 k.cal. heat removed respectively for the 12-stage evaporation and ammonia refrigerant processes.

REFERENCES

[1] S. L. Martin: INTERNATIONAL CHEMICAL ENGINEERING, 1951, **32**, p. 221.
[2] 'Vacuum Physics,' *J. Sci. Instr.*, Supplement No. 1, July 1951.
[3] Davy: 'Industrial High Vacuum,' Pitman, London, 1951.
[4] Magner: 'Erzeugung u. Messung von Hochvakuum,' Deuticke, Vienna, 1950.
[5] Holland-Marten: 'Vakuumpumpen in der Verfahrentechnik,' Knappe, Halle, 1951.
[6] *Idem:* 'Die Vakuumimprägnierung,' Knappe, Halle, 1951.
[7] Benedict and Williams: 'The Gaseous Diffusion Process,' McGraw-Hill, New York, 1949.
[8] Hintenberger: *Z. f. Naturforschung*, 1951, **6**, p. 459.
[9] Martin: INTERNATIONAL CHEMICAL ENGINEERING, 1949, **30**, p. 456.
[10] Flosdorf: 'Freeze Drying,' Reinhold, New York, 1949.
[11] Hellier: *Food Industries*, 1949, **21**, p. 1191.
[12] Niedergall: *Chem. Ing. Technik*, 1951, **23**, p. 113.
[13] Badger and McCabe: 'Elements of Chemical Engineering,' McGraw-Hill, New York, 1936.
[14] Hammer, Messing and Schenck: *Chem. Ing. Technik*, 1951, **23**, p. 513.

Acknowledgments

All illustrations are from *Vacuum Physics*, Supplement No. 1, J. Scientific Instruments. Fig. 1, E. D. Malcolm, 'Melting and Sintering of Metals in Vacuo,' p. 64; Figs. 2 and 3, L. Riddiford, 'The Vacuum System of the Birmingham Proton Synchrotron,' pp. 53, 54; Fig. 4, L. Holland, 'Recent Advances in Vacuum Coating Plant and Techniques,' p. 61; Fig. 5, D. R. Goddard, 'Large-Scale Vacuum Dehydration,' p. 45 and 'Food Industries.'

Chemical Plant Construction

About 170 graduates and students attended the Symposium on Chemical Plant Construction organised recently by the Institution of Chemical Engineers Graduates' and Students' Section in London. Four papers were read, two dealing with plant fabrication and two with plant erection. Fabrication in non-ferrous metals and stainless steel and fabrication in ferrous metals were described separately. The two papers on plant erection described the erection of the Fawley oil refinery and the Manchester petroleum chemicals plant. Below are summaries of three of the four papers. It is hoped to publish the fourth paper 'Fabrication in Ferrous Materials with particular reference to Pressure Vessels,' by H. B. Fergusson, more fully in a later issue.

Fabrication in non-ferrous metals

FABRICATION of non-ferrous plant and unit plants for special products was described by G. A. DUMMETT, Scientific Manager, A.P.V. Co., Ltd., who was introduced by C. M. AUTY, Technical Director, W. J. Fraser Ltd. Mr. Dummett said that in many cases the fabrication of stainless steel plant was akin to the fabrication of non-ferrous metal plant. These materials were in general expensive and, therefore, only used where corrosion-resisting plant was required or where contamination of the product had to be avoided. Most of the plant in these metals was in comparatively thin sheet, except when required for high-pressure vessels. In some cases the metal was fitted inside the vessels as liners, in others a duplex material employing a thin layer bonded to a thicker layer of, say, mild steel was used to form a clad structure.

There were five main methods of fabricating plant in metals, namely, (a) casting, (b) hot working, (c) cold working, (d) machining, (e) joining. Casting produced a large grained structure which was, therefore, mechanically weaker than wrought material. Extrusion was a useful method of fabrication for parts such as T-sections. In general, it was only carried out by specialist firms.

Hot working or forging provided a useful method of fabrication with a satisfactory grain size material, for heavy shaped parts, pipe bends and similar parts. In this method, the finishing temperature had to be as little above the annealing temperature as possible. However, some metals could only be hot worked in a limited temperature range as they became brittle above their temperature of crystallisation, *e.g.* Monel metal had to be worked at 1,040-1,150° C.

Cold working followed by welding provided the essential method of construction of non-ferrous metal plant. In some instances the metal could be hammered into the required shape, *e.g.* elaborate copper vessels were given both shape and finish by hammering. By this process, however, the metal work-hardened, and might eventually become either too hard to work or crack. This was overcome by causing small successive deformations and by annealing, softening the material by heat treatment between successive stages of deformation. Increased mechanisation, *e.g.* the use of rotary cutters and nibblers, had considerably helped in the development of the cold working methods, which also included stamping, rolling, deep drawing and spinning.

Machinability of metals was an important factor. Homogeneous single phase metals, such as copper and aluminium, deformed relatively easily and were, therefore, difficult to machine. Often a small amount of another metal was added to improve this property, *e.g.* as lead was added to gun metal. Another example was that 60-40 brass machined more easily than 70-30 brass, due to the presence of a second brittle phase in the latter.

Grinding on a refractory wheel was used for hard metals, such as silicon iron or *Hastelloy D*. Silicon iron was one of the finest corrosion-resisting metals but it could not be machined and its shape, therefore, was limited to cast forms. Grinding was often used for finishing welds. Other finishing methods included electro-polishing which gave a good burnished finish, and tumbling.

Joining could be carried out by (*a*) riveting, which formed a joint very susceptible to corrosion and should normally be avoided, (*b*) soldering or brazing, which was often liable to corrosion and might be weak, and (*c*) welding. Welding was by far the most important method and various techniques could be employed according to the material and circumstances. Argon arc was useful because it allowed the use of various forms of joints unacceptable with metallic arc or oxy-acetylene welding. Work was at present proceeding on the inert gas-shielded metallic-arc method.

The building of Fawley refinery

The planning and construction of large plants was described in a paper by R. J. COLE, Project Manager for Foster Wheeler Ltd., Fawley Refinery, Southampton, which was read in his absence by P. LIGHTFOOT, Planning Assistant at Fawley, who was introduced by F. E. WARNER, Chief Chemical Engineer, Carless, Capel and Leonard Ltd. Much study and forward thinking went into the planning of the erection of a plant and in order to provide an actual example the speaker based his account on experience with the £40,000,000 Fawley oil refinery project (see this journal, October, 1951, p. 471-472).

Engineering, procurement and erection were the three main phases of a construction programme and had to be co-ordinated carefully in order to build the project in the shortest possible time. The man days for the various phases of the project were estimated and a composite graph drawn showing the overall length of the project and the volume of manpower distributed during the period according to the demands of the job. From this, it could be seen in the early stages whether or not it would be possible to procure and maintain a construction force of the size needed. The labour situation had to be gone into very carefully.

Simultaneously a field survey party including representatives of the customer went to the site and boring surveys, etc., were set in motion to determine the need for piling and the general make-up of the terrain. The availability of building materials, as well as transport for heavy materials were investigated. All local building restrictions were investigated and governmental agencies contacted.

Availability of clerical staff was ascertained and the hiring of key departmental staff begun. All projects presented different conditions and it had to be remembered that the speaker was describing the Fawley refinery which was built for Esso Petroleum Co. Ltd., by Foster Wheeler Ltd., who decided to handle the erection of the whole process plant phase without the benefit of sub-contractors.

The project was set up in the following departments: camp manager, personnel manager, safety officer, material receiving, accounts, office manager, purchasing agent, *x*-ray technicians and inspectors, chief field engineer with assistant field engineers for each phase, a concrete and aggregate superintendent, an off-site and on-site superintendent, a complete mechanical department headed by a master mechanic, a complete instrument department headed by an instrument technician, and top field superintendents in charge. Equipment supervisors were then set up working jointly for off-site and on-site operations. In all there were 61 supervisors for a labour force of 5,500.

The office manager on this project played a very important part as he was responsible for all expenditure from pay rolls to material billings. The office end of the project was handled by an automatic machine accounting system, which worked very well.

A transport department had to be set up as the nearest town, Southampton, was

18 miles away and at the peak of construction the company were operating in the neighbourhood 100 buses and four trains daily. Every worker was covered by a single agreement made in collaboration with the Confederation of Ship Building Engineers. The effectiveness of this agreement is illustrated by the expenditure of some 16,800,000 man-hours with a loss, due to industrial dispute, of less than 1,000 man-hours.

Fifteen months after the job started, the whole project was rephased and the manpower rescheduled as it was clear that certain operable sections would be finished and available before others and from the customer's point of view it was very advantageous to start up as soon as possible.

All mechanical repairs and all pipe fabrication and miscellaneous steel fabrication, except main structures, were carried out on site and an extensive welders' training programme was instituted. Specialist training for instrument action was also started early in the job and also proved a great benefit. All pressure vessels were field fabricated, erected and *x*-rayed in the field which was, needless to say, a big operation with the large pressure vessels varying from 5-56 ft. in diam.

The customer set up a field organisation which approved all expenditure, inspected the work done and accepted the finished plant. Red tape was quickly cut by a resident engineer in charge, aided by a competent staff. This allowed the project to go ahead without undue delay.

The selection of top supervisors was one which was approached carefully, resulting in the engagement of men with good mechanical ability and good constructional knowledge as well as men with a knowledge of handling large labour forces.

In reply to a question, MR. LIGHTFOOT stated that in making their original labour estimates they employed the factor of two British man-hours equivalent to one U.S. man-hour. However, after a short while this figure was reduced to 1.5 and is now put at equal. The explanation of this is that given the organisation and materials the British workman is as good as the American.

A petroleum chemicals plant

Problems encountered in the erection of a petroleum chemicals plant were described by H. E. CHARLTON, engineer-in-chief, Petrocarbon Ltd., who was introduced by K. B. ROSS, formerly general refineries manager in Persia for the Anglo-Iranian Oil Co. Ltd. Mr. Charlton discussed this subject with special reference to the plant built at Manchester which was designed to crack about 75,000 tons p.a. naphtha, yielding a liquid and gaseous product from which a full range of pure chemicals could be separated or synthesised. The erection of this plant was almost the converse of the Fawley project since a good deal of improvisation was necessary and the plant items required were not so readily available. The plant was, however, now working up to and beyond design capacities.

The difficulties encountered arose from many causes, namely, policy, technical, material, human and administrative problems. As the process on which the whole development was based was to some extent speculative, the first problem was to determine the size of the plant bearing in mind the necessity of not making the experiment on too large a scale, but at the same time ensuring that it was an industrially economic size.

The plant was built to the smallest economical size but as it was imperative that future extensions could be made in an easy and economical way, the first cost of the plant was slightly increased.

The individual components comprising the various plants were very small compared with a large oil refinery, the weight of the largest fractionating tower being only 41 tons. To facilitate the erection of the very large numbers of smaller loads, special lightweight erection masts were used.

The way in which this plant was constructed could not be considered typical as the design and construction were carried out to a large extent contemporaneously, and a large amount of construction work was done by direct labour. If the more conventional method of placing orders for the complete plants with one or more contractors had been followed, then, under the prevailing circumstances, this plant would only have reached its present state some years later. By employing direct labour greater mobility was obtained and it was possible to move gangs from plant to plant as designs, materials, weather conditions and other conditions warranted.

Mr. Charlton then gave instances of the different problems encountered. For example, the company were warned by the suppliers of the low temperature vessels that there might be a slight degree of porosity at the point where the heavy flanges run into the shell, but that this porosity would not adversely affect the strength of the vessels. Some of the vessels, in fact, were porous, but in all cases a satisfactory solution was found by either homogeneously lead-lining that part of the vessel, by drilling and plugging the defect, or by arc welding or foundry fusion in bad cases, and in some cases by *Bakelite* varnish impregnation under vacuum.

Valves for dry gases are often provided with soft composition seats. In the gas separation plant where the temperatures were very low, such material was out of the question, and it was found from bitter experience that normal bronze globe valves were not at all satisfactory under these conditions. One of the defects of these valves was that the seats were not properly guided and, therefore, did not close on precisely the same surface each time. It was found that by designing a special valve and seat where the valve was firmly guided at the top and bottom, it was possible to get a valve which was tight on dry gases. The design involved modifications which were quite expensive, the new valve and seat costing about the same price as the initial cost of the valve itself but the expenditure proved worthwhile.

In the ethylene oxide plant, the chlorinator towers, where ethylene is reacted with hypochlorous acid to form ethylene chlorhydrin, were originally erected in unprotected chemical stoneware. These towers consisted of a number of 5-ft. diameter sections. The supporting of these vessels was very carefully studied to avoid incurring undue stresses, particularly at the junctions. All these precautions were not sufficient to prevent breakages, and it was finally decided to armour the stoneware with an external steel casing, filling the annular space with special cement. The towers were said to be giving very good service now and it was recommended from this experience that where stoneware larger than 3 or 4 ft. diameter was used, it should be armoured. Other towers used were brick-lined steel, an alternative method of construction, which had proved satisfactory.

Mr. Charlton pointed out that in emphasising the difficulties encountered one was apt to give the impression that the plant was carelessly designed and constructed. This was not the case and he believed that considering the magnitude of the task and the period of time in which the construction took place, the small number of problems and errors was a tribute to all those who took part in this project.

There were many other problems which were non-technical but which the chemical engineer might be required to handle, *e.g.* the handling of labour and prevention of labour disputes and the organisation and maintenance of the administrative staff.

'C.P.E.'—August

Articles next month will include:

Automatic Control in the Process Industries, Part 2: Process Controllers by A. Pollard, B.Sc., A.R.I.C.

Design and Layout of Radiochemical Laboratories by J. W. J. Fay,. Ph.D., D.I.C.

Chemical Engineering Review: Metallurgy by H. A. Holden, M.Sc., A.R.C.S., D.I.C., A.I.M.

An Industrial Electrodialysis Cell

First Five Years of Atomic Research at Harwell

THE first connected story to be published of the work and problems of Britain's Atomic Energy Research Establishment, Harwell, from its inception in 1946 until the end of 1951, has recently appeared.*

It gives an account of the main research programmes and of the progress that has been achieved in them. An attempt has been made to satisfy the interest of the general reader, and at the same time to summarise for the more technical reader the advances in new fields of research. It does not deal with the production organisation; nor does it set out to give a statement of the Government's general policy in the atomic energy field.

The production and use of atomic energy demands the closest co-operation of almost every branch of the physical and biological sciences. A study of the way in which these are integrated is itself of considerable interest, but as this book shows again and again, the successful development of atomic energy depends not only on integration but on pushing out the frontiers of knowledge in all these sciences simultaneously.

After giving a brief account of the events leading to the formation of the Atomic Energy Research Establishment in 1946, and a review of its organisation, there is an outline of the main tasks on which Harwell is working.

These are treated under four heads:

(1) The production programme.
(2) Isotopes.
(3) Nuclear reactors.
(4) Particle accelerators.

The work going on in these four fields is described in some detail.

Plutonium piles

During the first few years Harwell's main task was to supply technical information to the atomic energy production organisation centred on Risley, particularly in connection with the design of the plutonium production piles and chemical separation plant at Sellafield in Cumberland.

In this field it has been possible to give only a general picture of the problems that were tackled, but it is interesting to see that, in common with most modern engineering installations, success depends on attention to minute detail. It has, for example, been necessary to develop a highly sensitive method for detecting the failure of even one of the thousands of aluminium ' cans ' that enclose the uranium fuel elements, so that the defective element can be removed before it discharges any radioactive material into the cooling air.

* ' Harwell,' the first official account of British atomic energy research since 1945. Published by H.M.S.O., 6s.

Radioisotopes

The next main programme covered is the production and use of radioisotopes. All this work is non-secret, and a great deal has already been published about it. The book surveys the methods of producing isotopes and their applications. A new use in the medical field is shown in an illustration of a skin graft operation. The injection of a radioisotope into the graft has enabled surgeons to find whether the graft has taken, and so to proceed more quickly and with more certainty of success to the next stage of the operation.

Reactors

An account is given of work on the development of new types of reactor for the production of useful power. It is shown that there are many factors in the design of these reactors, such as the type of fuel, coolant, moderator and canning material, and whether fission is to be caused by fast or slow neutrons, or neutrons of intermediate velocity.

Since reactors are extremely costly, it has been necessary to devote considerable time to studying the possibilities, particularly when the technological resources for building are limited as they are in the United Kingdom. As a result of this study three types of reactor have been chosen, and from recent statements by Sir John Cockroft it is clear that a building programme is under consideration.

Many new technical problems have to be tackled in the course of a reactor development programme. Among those mentioned are the use of new materials such as beryllium and zirconium, about the metallurgy of which very little is known, the use of liquid metal coolants for achieving very high heat-transfer rates and the effects of very intense nuclear radiation on materials. Most of these problems will arise whichever reactors are chosen for building, and a study of them has been going on in parallel with the studies mentioned in the previous paragraph.

Particle accelerators

A programme of work more in the research field is the development of particle accelerating machines for speeding up atomic particles to very high speeds and energies.

Two things not widely known emerge in this account. First is the way in which the British lead in synchrotron and linear accelerator design has sprung from their war-time radar experience—an A.E.R.E. group working at the Telecommunications Research Establishment, Malvern, had the first synchrotron working there in August 1946 and the first linear accelerator in November of the same year.

The second is the use of these accelerators in radiotherapy, and collaboration with the Medical Research Council in choice and design of the most suitable machines is described.

A very important part of the supporting programme at Harwell is the service given by the Medical and Health Physics Divisions in collaboration with the Medical Research Council and others. To ensure that no one inside or outside the Establishment shall be exposed to harmful amounts of radioactive or toxic materials is a major task. The way in which the many and various problems have been successfully overcome is described in detail.

Some of the fundamental research at Harwell in the fields of physics, chemistry and metallurgy is described. While the physics research is principally concerned with the investigation of the nucleus, using such tools as the Van de Graaff accelerator and other high energy machines, a great deal of study is also given to the effects of irradiation, particularly pile irradiation on aggregates of atoms. Accounts are given of various pile experiments which yield information on cross-sections of elements for the absorption of neutrons, lattice changes under irradiation, neutron diffraction by crystals, and nuclear transformations under neutron bombardment.

Chemical research

Much of the pure research in chemistry has naturally been directed towards the study of the heavy elements and, beyond them in the periodic table, the artificially created transuranic elements, and the book describes various investigations which have taken place, particularly into the electron configurations of the transuranic elements. The measurement of magnetic susceptibilities, self-diffusion of ions in solutions, experiments with the Hahn emanation technique, and the production of new radioactive elements by photodisintegration are also described.

In radiation chemistry, studies have been made of the effects of irradiation on water and aqueous solutions, and of the effect of pile radiation on the chemical processes of oxidation and corrosion—both of great importance in pile design.

In analytical chemistry, very sensitive techniques for the detection of trace elements have been developed—a method has been perfected, for instance, by which strontium in sea water may be detected at a concentration of 10 p.p.m. with an error of $\pm$ 10%.

Metallurgy

Many of the researches in metallurgy are of fundamental interest in metal physics,

such as the study of the unusual crystal structure of uranium, which at room temperature is orthorhombic in form. Uranium alloy systems, powder metallurgy, the examination of metals under polarised light, the effects of irradiation on the mechanical properties of metals, fabrication of high-temperature materials such as alumina and zirconia are other metallurgical subjects which are reviewed here.

A final chapter describes Harwell's extra-mural relations in two important categories; collaboration through research and development contracts which have been placed with academic, industrial or Government laboratories, and the exchange of scientific and technological ideas and information by way of published papers in the scientific journals, lectures, training courses at the Harwell Isotopes School, symposia and conferences.

A list of nearly 300 published papers by Harwell staff forms an appendix to the book. A second appendix gives details of the two Harwell piles, Gleep and Bepo. (These were described in INTERNATIONAL CHEMICAL ENGINEERING, 1951, January (pp. 27-29) and August (pp. 383-385) respectively.) Reading lists in atomic energy are also provided. The book is freely illustrated by photographs and drawings.

In general, the book should be fairly straightforward reading for anyone acquainted in broad outline with present theories about the structure of the atom and the nucleus, and about the fundamental particles of matter. Such terms as electron, proton, neutron, mass number, atomic number, isotope and so forth are used in the report without explanation, though for the guidance of the non-scientific reader a glossary of the more important technical terms is included at the end of the book. The account of progress in fundamental research inevitably makes considerably greater demands on the reader's scientific knowledge and experience.

I.C.I. in 1951

LAST year Imperial Chemical Industries Ltd. increased the value of their sales by 19% over the all-time record for 1950. Total sales were no less than £262,800,000, of which £57,900,000 were direct exports, compared with £48,400,000 in 1950. At the same time the gross capital expenditure on new physical assets by the company and its home manufacturing Divisions during the year amounted to nearly £25,000,000, and there were contracted commitments at the end of the year for fixed capital expenditure amounting to over £22,000,000. Expansion of production facilities was not the only reason for increased sales, since considerable attention has been paid to improving the efficiency of production by means of instrumentation, mechanisation, work study and better fuel efficiency. All Divisions reported a shortage of raw materials and in many instances demands exceeded supplies, although demands from overseas countries declined towards the end of the year on account of increased competition from Germany and America. Here are brief details of I.C.I. developments in chemical production facilities and research projects during 1951, summarised from the recently issued annual report.

The company operates more than 100 factories in the U.K. which are engaged in the manufacture of products ranging from heavy chemicals and metals to drugs and synthetic fibres. Manufacture is carried on in 12 Divisions.

Alkali Division. The first stage of the post-war extensions has been completed and is in full operation; the second stage is in hand and will be brought into use during the next few years. Progress has been slower than was hoped, on account of shortages and the heavy load being carried by the U.K. engineering industry.

Polythene is being developed under the trade name, *Alkathene*, and substantial dollar royalties have been received for some years now from American manufacturers. More recently licensing agreements have been made for the manufacture of polythene in France and Italy. Part of the new *Alkathene* plant at Wilton was completed and brought into operation at the end of the year, and the rest of the plant will be in production during 1952. During the year plant was installed for the liquefaction and transport of ethylene. The ethylene is produced by the Wilton olefine plant, liquified in the *Alkathene* plant and then transported by tank wagon to Winnington Works, Cheshire, where it is vaporised and used in the *Alkathene* plant there. This carriage of liquid ethylene over a distance of approximately 150 miles is a novel development needing specialised technique and equipment, and is unique in Britain.

General Chemicals Division. There was a shortage of sulphur during the whole of the year. However, the company had made plans to convert some of its sulphuric acid plants based on sulphur to the use of other raw materials. Some of these conversions were completed during the year and others will be completed in 1952. I.C.I. has also joined with other users and manufacturers of sulphuric acid to form a new company, United Sulphuric Acid Corpn. Ltd., which will operate the anhydrite acid process in a new plant being built on Merseyside.

Since the war the company has considerably increased its production of chlorine, and the building of new plants is well advanced. Although production was some 15% higher in 1951 than in the previous year, the company was still unable to meet the high demand, which continues to increase.

Increases in output of *Gammexane* insecticides and in selective weedkillers are being planned.

Lime Division. Since the limestone quarrying operations at Tunstead were mechanised in 1945, the output of limestone has increased by more than 1,000,000 tons p.a. Raynes Quarry, North Wales, which supplies limestone by sea to the company's alkali works at Fleetwood, was mechanised in 1948 and mechanised ship-loading and stockpiles are now being provided so that production will not be interrupted by shipping difficulties caused by storms.

Salt Division. The new vacuum plant at Stoke, near Droitwich, which was started up in the latter half of 1950, was brought into full production, and it is probable that it will produce considerably more than its design capacity. The substitution of vacuum salt for salt made by the open-pan process, and two new types of salt, granular and dendritic, which are made by multiple-effect evaporation, have materially helped this change-over. These two types have advantages over the conventional open pan or solar salt in several respects.

Dyestuffs and Pharmaceuticals Divisions. Output of every type of product in the Dyestuffs Division was increased and, although efficiencies were improved, the steady rise in the cost of raw materials forced the Division to increase the price of its products. Even with the considerable expansion of plants over the last few years, there has been a shortage of certain products, both dyestuffs and non-dyestuffs, and several new large-scale projects are now in hand. Output of nylon polymer is to be trebled and a new phthalic anhydride plant is being designed. A large new plant which will increase the output of *Monastral* blue, a pigment of all-round fastness, will come into production in the first half of 1952. The production of sulpha drugs for the Pharmaceuticals Division will be increased still further. As a result of research it has been possible to add 13 new dyestuffs and four non-dyestuffs to the company's selling range.

There were no price increases in the company's pharmaceuticals, and substantial reductions were made in the price of penicillin products.

Billingham Division. Production of fertilisers amounted to some 800,000 tons, which (together with 272,000 tons of sulphate of ammonia from the Prudhoe Factory which the Division manages on behalf of the Government) was an important contribution to food production.

During the year, the Division's plants at Wilton (for the production of petrol, form-

aldehyde, ethylene, ethylene oxide, ethylene dichloride, and glycol) and at Billingham (for the production of nonanol, *Alphanol*, acetone, isopropanol and methylamine) came into production. At the end of the year the new *Nitro-Chalk* plant at Heysham was started up which, when it is in full production, will add 100,000 tons p.a. to the Division's production of fertilisers.

The loss of petrol supplies from Abadan increased the demand for home-produced aviation spirit, and the petrol plant at Billingham turned over to this grade of spirit. The consequent loss of motor spirit was made good by the new production from the olefine works at Wilton.

With the Division's plants working to capacity, and the products of the new plants being sold as soon as they are available, constant thought is being given to ways and means of meeting increases in demand; and extensions to the ammonia, nitric acid and sulphuric acid plants have been started, and schemes for other extensions and new products are in varying stages of development.

The Division's technical and engineering staff have advised and assisted I.C.I. overseas companies in their manufacturing schemes, and they have also been frequently consulted by outside firms both at home and overseas. Although the company is not a supplier of chemical plant, these activities often lead to contracts for plant being placed with British firms.

Wilton Works. The first stage of development of the Wilton Works covers the construction of 10 manufacturing plants belonging to five of the company's Divisions. Of these plants, the *Perspex* and the phenol formaldehyde plants came into production in 1949. Seven new plants were brought into commission in 1951, and of these the formaldehyde plant, the olefine plant, the ethylene oxide and glycol plant and the *Lissapol* plant were in substantial production at the end of the year, and the alpha-naphthylamine plant, *Alkathene* plant and the urea formaldehyde plant were in part production. The main work remaining in the first stage of development is the completion of the chlorine plant, the power station and sections of the urea formaldehyde plant. During the year construction work was started on the second stage of development covering two further *Alkathene* plants, a *Terylene* plant and a phthalic anhydride plant.

Metals Division. Throughout 1951 the Division was short of raw materials. Although long-term prospects for improved supplies of copper, zinc, nickel and aluminium, which are the major raw materials of the Division, are promising, the prospect of increased supplies in the immediate future is not encouraging. Lead was one of the few materials in good supply but owing to the high price of this material the demand for lead products was disappointing.

During the year production started at the new modern tube mill at Kirkby, Liverpool, and steady progress was made towards the completion of this and other schemes for modernising the Division's plants.

A subsidiary, Fyffe & Co. Ltd., manufacturers of non-ferrous pipe fittings, which are an adjunct to the Division's sales of tubes, had a record volume of sales notwithstanding the shortage of raw materials.

Nobel Division. One of the causes of the record demand for blasting explosives is the increasing proportion of explosives used in coal mines to each ton of coal raised, and the indications are that this tendency will continue.

A modern explosives factory is to be constructed on a new site in Yorkshire, from which the local mining industry can be supplied quickly and with the minimum of freight charges. It is also proposed to erect an additional pentaerythritol plant.

The *Ardil* fibre plant was opened in February 1951 but, unfortunately, suitable supplies of the raw material, groundnut meal, were not available until October. Most of the teething troubles associated with a new plant have been overcome. The plant will produce a relatively cheap fibre of wool-like properties.

In spite of American and German competition as well as shipping difficulties, this Division made record sales overseas of nearly all its products.

Leathercloth Division. Despite adverse trade conditions, steady improvements in manufacturing processes, and new designs and additional uses for the products are being developed, and sales of the Division were greater than in 1950. A decline in the sale of *Rexine* (nitrocellulose coated fabric) was amply compensated for by an increase in sales of *Vynide* (PVC-coated fabric).

Paints Division. Although there was an increased demand for paints there was only a small expansion in production and sales on account of shortages of the more important raw materials. Much of the work in the laboratories was devoted to making the best possible use of raw materials. The development of new and improved processes for the manufacture of synthetic resins and pigmented products was completed, and the necessary new plant is in the course of design and construction.

Paint manufacture was started in India by the company's subsidiary, Alkali & Chemical Corp. of India Ltd. In France the company obtained a holding in a French paint manufacturing company.

Plastics Division. Increased supplies of phenol formaldehyde moulding powder are being produced at a new plant at Wilton Works. The new urea formaldehyde plant at Wilton started production at the end of the year and will be producing substantial quantities this year.

Owing to the rapidly growing demand for plastics for new industrial applications, the fall in demand for consumer goods is not expected to have a serious effect on the volume of sales. Since 1952, the Division's exports have increased five-fold.

'Terylene' Council. The basic design of the *Terylene* polymer and spinning plants has been substantially completed, and work on the site started early in 1952 in accordance with a programme which aims at simultaneous completion of all sections at the earliest possible date.

Overseas activities

I.C.I. sold more in Europe during the year, particularly to Yugoslavia. A dyestuffs sales office has been formed in Norway. In Africa the associated company, African Explosives and Chemical Industries Ltd., increased production and sales of fertilisers and explosives. I.C.I. (South Africa) Ltd. doubled its turnover to £2,000,000, an increase of 50% on 1950. In the Near East sales were good but in India there was a decline owing to the heavy purchases of the previous year caused by the Korea war. In China staff have been withdrawn, although some still remain in Shanghai and Tientsin. Good results were reported from I.C.I. branches and undertakings in Pakistan, Malaya, Indonesia, Canada, Brazil and Argentina. However, the new subsidiary in the U.S., Arnold Hoffman & Co., had a poor year owing to the widespread depression in the textile industry. A new *Soledon* dye plant was almost complete at the end of the year and further increases in dyestuffs manufacture are being considered.

Research and development

During the year the programme of extension of the research laboratories of the **Dyestuffs Division** at Blackley, near Manchester, was completed with the opening of a new wing of more than 30 laboratories, bringing the total to 70 laboratories on this site. The construction of new laboratories for work on **plastics** has been started at Welwyn Garden City.

Early in the new year, a new semi-technical laboratory was opened at the **Metals Division** headquarters. The plant includes a rolling mill, hydraulic and mechanical presses, a tube drawing bench and other equipment not generally available solely for experimental purposes.

The company's **Creep Test Station** came into full operation during 1951. The whole battery of 36 large machines for the accurate study of the creep of metals under load at elevated temperatures, and the 24 smaller machines are now in use.

An intensive study has been made of the process of burning **limestone.** A special machine has been designed for the study of the deformation of metals at elevated temperatures. In the fine chemicals section work on **chemotherapy** is advancing as well as investigations on nutrition of fungi and certain antibiotics.

The rising cost of many raw materials, combined in many cases with increasing scarcity has necessitated a careful review of established processes. In some cases

it has been possible to cut down the use of scarce materials or even to substitute others. To replace **superphosphate,** the Billingham Division has worked out an alternative to the sulphuric acid treatment of phosphate rock which gives a nitrophosphate fertiliser; the process which has reached pioneer plant scale, uses nitric acid instead of sulphuric acid.

Research is being carried out on the economical production of **titanium metal.** A small scale plant has been built by the General Chemicals Division for the production of titanium sponge, at a rate of approximately 100 lb./day, and has been brought into successful operation. This sponge is being melted and cast into ingots in specially designed furnaces in the Metals Division, which are being fabricated into rod, sheet, wire, etc. Work is actively in hand on alternative methods of extraction, improved methods of melting, strength characteristics at room and elevated temperatures, welding and manipulation, and corrosion and resistance of titanium and titanium-rich alloys.

All stages in the manufacture of **Terylene** synthetic fibre have been investigated in order to complete design data for the large-scale Wilton plant. A pioneer plant was built and put into operation during the year.

Agreements were concluded during the year with the International General Electric Company of America and the British Thomson-Houston Co. Ltd., whereby I.C.I. will obtain rights to manufacture **silicones** according to the I.G.E. patents and processes. A plant is to be erected to produce silicones and other organo-silicon compounds.

The **nonanol** and **'Alphanol 79'** plant is the first in this country to use the high pressure carbonylation technique on a commercial scale, and although novel in many respects, smooth running was quickly achieved. The products are mainly used in the manufacture of plasticisers.

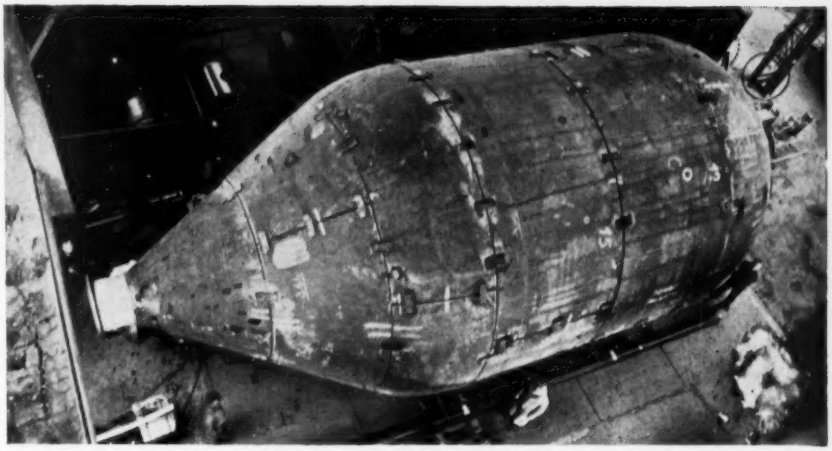
The world shortage of **glycerin** and the consequent increase in price have led to a resumption of the work undertaken some years ago by the Nobel Division on the manufacture of glycerin by fermentation. The work is passing through the semi-technical stage and a pioneer plant is in the course of erection. This may well lead to large-scale production within the next few years.

A **fluorine** laboratory unit has also been developed by the company which is simple to operate and which produces fluorine with little trouble. For the past two years the company has provided these portable units to research workers outside the company at a small rental.

A plant for the production of **cyanogen chloride** is being erected to provide larger supplies. It is hoped to have this plant in production next year. A plant for the production of **trichlorphenol,** used in the manufacture of the selective weedkiller 2.4.5 T, is being erected.

Stainless Steel Clad Cellulose Digesters

By H. Canzler, Dipl.Ing.



Stainless steel clad mild steel cellulose digester with a capacity of 236 cu. m. for an operating pressure of 8 atm.

IN the sulphite pulp industry, corrosion-resisting steel containing 18% Cr, 10% Ni and 2.5% Mo (American Standard No. 316) has become the leading material for all plant items such as storage tanks, pumps, pipes, heat exchangers, liquor circulating units, valves, etc.

With the introduction of stainless steel cladding on mild steel plate, it has also become economical to use stainless steel in the construction of cellulose digesters. The thickness of the basic steel plate (of boiler plate quality) is about 25 to 30 mm., the thickness of the cladding usually 3 mm. The molybdenum content of the cladding material is 2 to 2.5%.

The composite plate is hot rolled from billets of the two metals, which explains the excellent bonding of the combined materials. Tests have proved that the basic metal and the cladding take up mechanical stresses jointly and, therefore, the total thickness can be introduced into the strength calculation.

The composite plates are formed to cylindrical, conical and hemispherical shapes. The separate parts of the shell are fitted together. In smaller digesters, all parts are welded together in the works and the vessel transported as a unit on special lorries to the cellulose factory or to a port. The shells of larger vessels are divided into parts and zones and these are welded together in the cellulose factory. In both cases, all welding seams are *x*-rayed.

Before the application of the stainless steel cladding, the mild steel of the digesters had to be protected by a lining of bricks. This took up 12 to 20% of the capacity of the vessel and had to be repaired or replaced periodically; even so there was the danger that brick or cement particles might be introduced into the cellulose. Cleaning of inner surfaces of stainless steel is very much easier and quicker than that of a brick lining. Connections, sieve arrangements, etc., can be easily fitted in a stainless steel digester. The life of such a vessel is practically unlimited. Higher costs of investment are more than balanced by greater capacity, better efficiency and safety, avoidance of repair or replacement of brick linings and prevention of stoppages for this purpose.

The Carl Canzler works, in Dueren, Western Germany, have 20 years' experience in the manufacture of stainless steel clad material. They have built vessels and apparatus of it with a total weight of some 8,000 tons. The welding technique for this composite material was originally developed by them. They have to date delivered a number of stainless steel digesters up to a size of 235 cu. m. and a working pressure of 8 atm., and they have large orders for such vessels from all parts of the world. The maximum size is about 300 cu.m.

Two more exploratory boreholes for **potash** were completed in the Whitby district during the year, and the drilling of another was started. Further evidence was taken of the presence of extensive deposits of sylvinite, a physical mixture of sodium and potassium chlorides, at a depth of 4,000 ft. Mining sylvinite at this depth is attended by a number of difficulties and in addition to taking expert advice on this method of extraction, the alternative of bringing the potassium salt to the surface as a hot concentrated brine has been under investigation. During the year a completed exploratory borehole has been converted to work as an experimental brinewell.

Corrosion Engineers' Conference

More than 30 papers on practical and theoretical aspects of corrosion in the chemical, oil and gas, refinery, electrical and other industries were presented at the eighth annual conference of the American National Association of Corrosion Engineers held at Galveston, Texas, in March. Here is a selection of abstracts of papers of direct interest to chemical engineers. A report of the Association's previous conference appeared in our June 1951 issue.

Stress corrosion cracking of steels under sulphide conditions

By C. N. Bowers, W. J. McGuire and A. E. Weihe

RAPID failure of tubing in a sour condensate well led to an extensive laboratory and field investigation to determine the corrosion cause and remedy for failures of tubing. Apparently failures occur because of stress corrosion cracking. Embrittlement resulting from exposure to moist hydrogen sulphide is not considered a primary cause of failures, but it may have been an important contributing factor. The exact mechanism of failure has not been definitely established, but the data show that most steels with mechanical properties in or above a critical range represented by Rockwell hardness C-24 to C-26 may be rendered susceptible to failure in hydrogen sulphide environment. The failure process can be prevented or appreciably retarded by suitable heat treatment and/or change in steel compositions. Susceptibility to failure of most steels is increased by plastic deformation. In most instances failures were more rapid in field tests, which indicated that the field operating conditions involving pressure, flow and formation water were more severe than the laboratory test conditions selected. In both tests there was little if any advantage for alloy steels over plain carbon steels. It was apparent, however, that for most steels, limitations on the maximum permissible mechanical properties are just as important and necessary as minimum limits.

Cracking of high strength steels in hydrogen sulphide solutions

By J. P. Fraser and R. S. Treseder

Laboratory data are presented relating to the spontaneous cracking and embrittlement of steel alloys under environmental and stress conditions pertinent to sour gas condensate wells. It has been shown that cracking can occur in simple aqueous hydrogen sulphide solutions, and is an effect related to stress corrosion cracking. A mechanism involving stress corrosion cracking and hydrogen embrittlement is proposed to explain the cracking phenomenon. Important factors studied included composition and heat treatment of alloy, type and magnitude of stress, composition of corrosive solution (*e.g.* acidity, salt content), composition and pressure of gas environment, temperature and time of exposure. Of these, the first three were found to be the most important. Remedial measures discussed include use of resistant alloys, heat treatment of susceptible alloys, organic and metallic coatings, and inhibition. A simple laboratory procedure is presented for making a preliminary evaluation of the cracking susceptibility of a given alloy.

Corrosion by sulphur and sulphur compounds at high temperatures

By E. N. Skinner, Jun., and W. Z. Friend

Based upon laboratory and field test data, an attempt is made to evaluate the different factors that influence corrosive attack occurring on heat-resisting alloys when exposed to hot sulphur-containing atmospheres. Particular importance is attached to alloy composition because of its effect on the fusion temperatures of the sulphide corrosion products and upon the mode of formation of these compounds at and beneath the metal surface. In general, the extent of attack is appreciably less severe under conditions which permit simultaneous formation of an oxide film. The sulphidation of pure nickel and high-nickel alloys induces pronounced embrittlement as a consequence of low-melting reaction products that are disposed principally in the grain boundaries.

Mercury and its compounds—a corrosion hazard

By M. H. Brown, W. W. Binger and R. H. Brown

Frequently cases of severe corrosion have been encountered with equipment fabricated of non-ferrous alloys that have long been considered standard for handling or processing a specific chemical. A review of the service history of such cases usually reveals the following pattern: (1) the equipment has functioned for considerable and even long periods of time without evidence of harmful corrosion; (2) suddenly, in a relatively short time, severe attack occurs. Routine examination failed to disclose the reason for the failures of equipment having such service records. Modified techniques for the examination of equipment having such histories of service reveal, in most cases, the presence of mercury in either the corrosion products, or on the metal surface in the vicinity of the attack, or in the environment. This observation instigated a series of studies on the role of mercury and its compounds in promoting corrosion of metals, the concentration levels that might cause serious attack, and the manner by which such substances could be transported through chemical equipment and plants. It was found that the vapour pressure of metallic mercury even at low temperatures is sufficient to permit the mercury vapours to pass through the system and alloy with many commercial metals. This amalgamation of such metals can result in stress cracking or severe corrosion. It has been shown that metallic mercury reacts with many environments to a sufficient extent to produce compounds that are corrosive to commercial metals. It has been demonstrated that concentrations of mercury compounds as low as 0.5 p.p.m. constitute a serious corrosion hazard for a variety of useful metals and alloys. The results of laboratory work and service experience have demonstrated that mercury contamination, either metallic or its compounds, constitutes a serious corrosion menace. It is believed that control of mercury contamination could easily be justified by the savings that would result from reduced replacement and maintenance of chemical process equipment.

KEL-F applications in corrosive systems

By L. C. Rubin and W. O. Teeters

A series of exceptionally heat-stable thermoplastic fluorochlorocarbons derived from chlorotrifluoroethylene and sold under the trade name KEL-F are highly resistant to a large number of chemicals. Their properties make them particularly attractive for use as thermoplastic protective coatings and in the form of moulded separators. Some aspects of the development work and results obtained in solving corrosion problems are presented. The use of KEL-F diaphragms in Saunders' type valves has solved many difficult commercial operating and corrosion problems. Suitably designed KEL-F 'O' rings and gaskets have solved gasketing problems in some highly corrosive systems. Other similar applications are being studied. The application of these coatings to protect metal surfaces exposed to corrosive systems is being studied *via* dispersions of finely divided plastic in a volatile vehicle. Preliminary data on the vapour permeability of films prepared from dispersion indicate KEL-F to be superior to most other plastic films tested. The performance of KEL-F protective coatings is dependent to a large extent on the molecular weight of the polymer. Molecular degradation of the polymer during the fusion operation and subsequent heat ageing is influenced by various metals; in some cases excessive degradation has resulted.

Corrosion by fluorine and fluorine compounds

By Ralph Landau

Fluorine is the most reactive chemical element. Every system of fluorine and metal is thermodynamically unstable, even at room temperature. That fluorine is successfully handled industrially in metal is due largely to the well-known phenomenon of a protective film. Stable films are formed on those metals into the atomic distribution of which fluorine fits with minimum distortion of the lattice structure. Such metals are nickel and Monel and, with less stability, aluminium, magnesium, copper, even iron. Fluorine reactions are characterised by high heat release. Reactions with surface contaminants on an otherwise stable protective film may be so rapid as to raise the backing metal to the ignition point. In the presence of water the reactivity of fluorine is governed by the fluorine ion and, since the tendency to form this ion decreases with increased concentration of the acid, concentrated hydrofluoric acid can be handled more easily than dilute. Fluorine's strong tendency to replace hydrogen from carbon, and oxygen from silicon, bars the use of those plastic and ceramic materials which have been employed successfully in the case of chlorine and hydrochloric acid. The range of fluorine-resistant materials is extended by the fluorocarbons, totally- or highly-fluorinated liquid and solid organic polymers. The fluorocarbons are useful materials to apply to that 1% of industrial systems, *i.e.* joints and glands, where 90% of troubles occur.

Laboratory method for the study of steam condensate corrosion inhibitors

By Harold I. Patzelt

A laboratory method for studying corrosion in steam condensate systems is described. In brief, a synthetic condensate is produced in a glass tower by aerating heated distilled water with a mixture of carbon dioxide and air. This condensate and a solution of the treatment are proportioned into a test container by gravity feed. A number of small steel test plates (coupons) are suspended in the latter and the liquid is mildly agitated with a paddle stirrer. At intervals a specimen is removed from the bath and the weight loss determined. The temperature, free carbon dioxide and dissolved oxygen of the synthetic condensate, and the treatment concentration are controlled throughout the test. Corrosion test data are presented for synthetic condensate systems in which sodium hydroxide, sodium polyphosphate, neutralising and film-forming amines and several other inhibitors are used. The effects of precorrosion of the test specimen and of contamination of the condensate with boiler water on the functioning of several types of inhibitors are described. The merits and limitations of the test method and possible interpretations of certain of the results are discussed.

Protection of off-shore petroleum production equipment

By H. L. Bilhartz and W. M. Thornton

This paper presents, through use of colour slides, the procedures of one operator for protection of off-shore petroleum production equipment. In the past two years, this operator has completed approximately 25 off-shore wells and constructed four off-shore tank batteries in Mustang Island Field, Corpus Christi Bay. Protective coating and cathodic protection are employed extensively for protecting well-head structures, tank battery platforms and flow lines. In general, cathodic protection is used for submerged areas while splash-spray zones and areas exposed to corrosive salt atmosphere are protected by coatings. The most severe corrosive attack occurs just above the water line in the splash-spray zone. Paint test racks were installed on one of the first well-head structures placed in Mustang Island Field. In the past eighteen months, approximately 100 test panels have been subjected to atmospheric and tidal zone exposure. Various vinyls, alkyd resins, asphaltic base, reclaimed rubber and coal tar protective coatings have been evaluated for this service. Vinyl coatings are used extensively as protection for areas subjected to atmospheric and splash-spray exposure. Well-head structures are coated on shore and barged to the site. Certain types of tank batteries are coated on location in the bay while submersible tank battery barges are coated at sheltered docks and towed to location. Proper application of vinyl coatings has been found to be of extreme importance in obtaining satisfactory coating service. All vinyl failures to date may be traced to poor or improper application techniques.

Cathodic protection of tank bottoms

By Scott P. Ewing and J. S. Hutchison

The problem in application of cathodic protection to tank bottoms is to determine when sufficient current reaches the central part of the bottom. It was found by means of measurements on models that current-potential curves or potential measurements in general are of no value for determining current requirements for tank bottoms, probably because the potential of the outer rim rather than the central part of the tank is measured. Current density on all parts of a tank bottom may be calculated for the case of uniform resistivity and no polarisation. For this case the efficiency of current distribution,

$$\frac{\text{Current density at centre}}{\text{average current density}}$$

is 50%. If the soil resistivity varies with depth the efficiency will vary. The paper shows how efficiency of current distribution can be estimated by means of four terminal resistivity measurements, taken near the tank. This method has the limitation that (1) it assumes that the soil at the place of measurement is the same as that under the tank and (2) it does not take into consideration coatings or pads under the tank. Another modified four-terminal measurement, which uses the tank bottom as one terminal, was devised by means of which the actual conditions under the tank are measured. Knowing the current density required for protection the above methods should provide a needed tool by which the effectiveness of pads and coatings could be determined together with the current required to protect the centre of the tank. The results presented in the paper were obtained mostly with models. The method needs further trials on actual tanks before it can be recommended for general use.

Corrosion resisting characteristics of iron modified 90/10 cupro nickel alloy

By W. C. Stewart and F. L. LaQue

This paper provides a summary of information on the corrosion-resisting characteristics of the iron modified 90/10 cupro nickel alloy which is currently being substituted for cupro nickel alloys of higher nickel content, particularly where resistance to attack by salt water is required. Following a brief review of the history of the alloy, information is included on the influence of iron content and heat treatment. The behaviour of the alloy under several conditions of exposure to attack by sea water is described. These conditions include quiet immersion, exposure at moderate velocity and at high velocity. With regard to the latter, data is presented as secured by jet impingement tests, erosion tests of various sorts, tests in model condensers and in piping systems. The paper also covers information on fouling characteristics and galvanic behaviour. In addition to the data referring to clean sea water, some experiences in sulphide polluted water are described. Appended also is information on the behaviour of the alloy in corrosive media other than salt water. Appropriate attention is given welded and brazed joints and some information on the physical and mechanical properties and heat transfer characteristics of the alloy is incorporated.

Economics of industrial maintenance painting

By Robert R. Pierce

The paper is based upon results of a research programme, still continuing, initiated by the Corrosion Engineering Products Department of the Pennsylvania Salt Manufacturing Co. some eighteen months ago to determine factors and materials which promote maximum pro-

tective life in Chem-Industrial painting. This research covers 429 individual studies of the protective value of 62 maintenance painting compositions of 10 different basis types. All determinations have been made in the operating process areas of three major chemical manufacturing plants, widely divergent geographically, in 14 different environments. Wire-brushed, corroded and blasted surfaces have been examined. No artificial or simulated exposures were used. Where performance comparisons were required, and in order to determine performances over surface irregularities normally encountered in maintenance painting, a new type test panel was used. The reliability of results from these panels was confirmed by 101 individual paint applications to actual operating plant equipment and structures. During the course of this programme, actual and projected protective life expectancies of various painting systems and procedures were determined, and converted to direct dollar cost and savings. Some of the results given are: (1) over 60% of the industrial maintenance paint compositions which by long experience have proven their adequacy in straight industrial use will fail rapidly when used for maintenance painting in a Chem-Industrial exposure; (2) surface preparation by blasting will increase by two to four times the protective life of the maintenance paint systems over wire-brushed corroded surfaces; (3) maintenance paint thicknesses below 5 mil. are undependable in aggressive Chem-Industrial environments; and (4) regular schedules of paint inspection and repair can reduce cost of plant protection to the magnitude of 5 cents/sq.ft./year even in aggressive Chem-Industrial exposures.

Stainless Steel Specifications

We regret that one of Dr. E. H. T. Hoblyn's statements at the above symposium was misreported by us (C.P.E., June). The remark referred to the submission of a report of the symposium to the B.S.I. accompanied by a recommendation for a certain course of action. We are sorry for this mistake, which occurred in condensing the full report, and gladly give Dr. Hoblyn's remarks on this subject in full:

'The symposium will have been of great value if it energises something; the subject has been well ventilated, but if we go away and do nothing then we might as well have never met. It is obvious that something must be done and I would like to conclude therefore with the thought—that a report on this symposium should be submitted to the British Standards Institution accompanied by the strong recommendation, which I am sure would not be necessary, that all parties concerned get together under the aegis of the B.S.I. to

(*a*) Revise, co-ordinate and condense the existing British Standard for stainless steels and to prepare new standards to fill any important gaps which are thereby created, without making changes just for the sake of change;

(*b*) Prepare a set of parallel specifications for substitute stainless steels, for present use and as an insurance policy in case of emergency.'

Plant and Equipment

New cemented carbide

The range of *Cutanit* cemented carbides produced by Metro-Cutanit Ltd. has been increased by the introduction of a new grade, 'W,' which contains no tungsten carbide, but has chromium carbide as its principal constituent. It is claimed to have high resistance to chemical corrosion, particularly by acids, and in addition has good wear resistance. It has a specific gravity almost half that of normal tungsten carbide grades and has a coefficient of thermal expansion very similar to that of steel. This latter property gives it a great advantage over tungsten carbide grades for applications in which the carbide is fixed into a steel matrix either by shrinking or brazing, especially where it is subjected to heat during working.

Grade 'W' is suitable for parts subjected to wear and/or chemical corrosion and, unlike other cemented carbides in the *Cutanit* range, is not intended for use as cutting tool tips. Development work is now just completed and a limited number of trial pieces can be supplied through the Cutanit distributors, William Jessop & Sons Ltd.

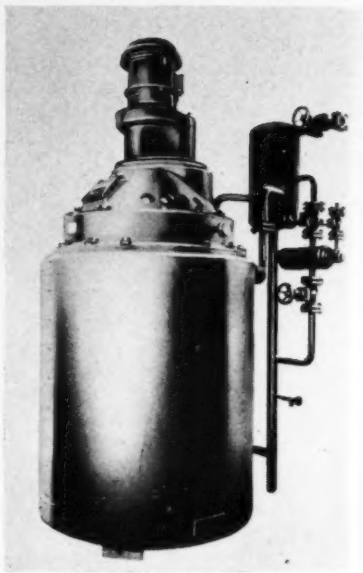
Soft ice refrigerator

In many industries there is a demand for refrigeration at temperatures ranging from 32 to 50°F. A new machine for preparing soft ice for such refrigeration has been marketed by the Creamery Package Mfg. Co. Ltd. It is known as the C.P. *Sabroe* soft ice machine and consists essentially of a double-walled cylinder with a tank underneath, in which the ice forms.

Soft ice accumulated during 12 to 16 hr. in the off-peak periods can be melted away in a very short time, due to its enormous surface area, without essential rise in temperature of the chilled water led to the plate coolers. When a uniform distribution of the returning ice-water over the entire soft ice basin is provided, temperatures close to 32°F. can be maintained as long as there is any soft ice in the tank.

These machines are made in seven sizes capable of a daily demand for latent heat storage of 1 to 100 tons of ice.

The ice produced is similar in consistency to crushed ice, and when the water is allowed to drain off the residue resembles snow. It is formed on the inside of a stationary vertical cylinder which is double walled; in the annular space ammonia is evaporated, thus cooling the inner drum. The ice formations of 0.004 in. thickness, on the inner surface of the cylinder, are removed by a rotating scraper. The crystals do not freeze together, but agglomerate to a spongy mass. When wet this retains an enormous surface area of soft ice which, when dry snow is preferred, allows water to drain off.



Soft ice machine.

Cold ice from the bottom of the basin is drawn out by the ice-water pump and circulated through the plate coolers, etc. The returning water is spread over the entire basin through a system of spray pipes. The water, which sinks through the soft ice, is effectively cooled before recirculation.

Because the freezing cylinder is stationary, there are no stuffing boxes for the refrigerant. The annular space for the evaporating ammonia is accurately controlled by a float valve system and the freezing cylinder is flooded with boiling ammonia, while the vapour escapes quickly without pressure drop into the liquid separator. This ensures dry, saturated vapour in the suction line to the condensing unit. The condensing unit can be erected beside the machine or remotely installed and, providing correct evaporation temperatures are maintained, the machine can be connected to existing condensing units.

Freezing water is sucked from the bottom of the soft-ice basin and led through the hollow scraper shaft carrying the water-distributing pipes which cover the inside of the cylinder with an even vigorous flow. The water only freezes as a thin layer on the cylinder, since the scrapers rotate at a speed of 30 r.p.m.

Power consumption is low and loss due to scraper action less than 5%.

The machine is installed above a basin, the size of which depends on the quantity of ice required. About 140 cu. ft. per 2,200 lb. is necessary, and the tank may be made of concrete, steel plate or wood. To prevent dew, it should have a slight insulation, while to save space it may be submerged, uninsulated, in the ground.

Rectifiers for insecticide manufacture

In the North Rand factory of the Klipfontein Organic Products, South Africa, DDT and benzene hexachloride insecticides are manufactured by a process involving the liberation of chlorine by the electrolysis of brine. Pumpless, air-cooled, steel tank, mercury arc rectifiers for the electrolytic plant have been supplied to the Klipfontein factory by the General Electric Co. Ltd. They comprise three 660-kW rectifier units giving a combined output of 4,500 amp. at 440 V, D.C. Each unit is arranged for grid control, a feature frequently incorporated in equipment for electrolytic service where the plant may be called upon to operate for long periods at reduced voltage. These rectifiers are scheduled to operate at constant load, without interruption, for periods of from three to six months. They are of the company's standard multi-anode design, of slide-arm construction embodying the *Vitric* seal for anode, grid and cathode insulation. The transformers and three-panel switchboard were also supplied by the company.

After this installation had been in commission for several months, it was decided to extend the plant up to the full capacity of the supply transformers by adding further lines of electrolytic cells. Three more twin-cylinder rectifier units, similar in construction to the original plant but rated at 807 kW, were thereby required, which will bring the total D.C. output of the station up to 10,000 amp.

Three 1,500 amp., 660 kW., grid-controlled, pumpless rectifiers supplying electrolytic cells at the North Rand Factory of Klipfontein Organic Products, South Africa.

Electric or hand-operated stacker

To meet the need for a stacking machine which can be used inside buildings with the use of power and also used in situations where no power is available, J. Collis & Sons Ltd. have produced a manual/electric stacker. The machine looks similar to the electric hydraulic stacker. The change-over from electric to manual operation can be made instantly. The usual control lever for raising or lowering the load is fitted and there is an automatic cut-out at the top and bottom of the lift. This new machine should prove useful when power fails through load shedding.

Pilot-scale rotary vacuum filter

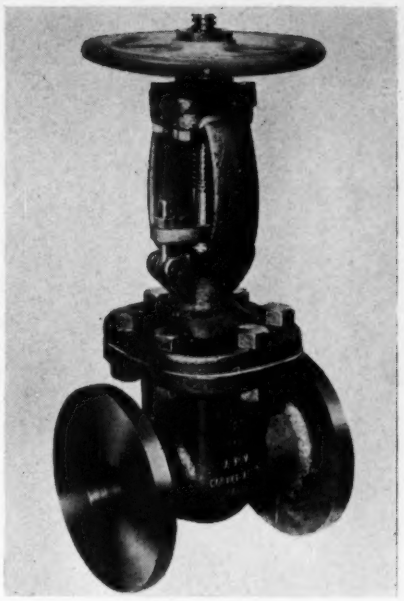
The *FEinc* continuous rotary vacuum filter consists essentially of a cloth-covered drum revolving in a tank filled with the slurry to be filtered. An agitator, oscillating gently backwards and forwards under the drum, keeps the solids in suspension. The surface of the drum is divided into shallow compartments which are connected by pipeline to an automatic valve so that the vacuum can be applied to each individually. A spirally-woven wire drainage member separates the cloth from the drum so that there is space for the mother liquor to drain from all parts of the compartment into the suction line. As the drum rotates each compartment goes through the same cycle of operation—filtering, dewatering and discharging the cake—controlled in repeating sequence by the automatic valve. Vacuum is applied to the submerged segments. This causes the mother liquor to flow through the filter cloth, internal piping and valve, while solids are stopped on the outside of the cloth to form the cake.

As sections emerge from the tank, the vacuum dewaters the cake as the drum carries it round to the point of discharge. When all the mother liquor that the particular filter cake will give up has been removed, the automatic valve cuts off the vacuum, and the cake is discharged from the drum by the *FEinc* string discharge. This method of discharge comprises endless strings spaced about ½ in. apart passing right round the drum. The cake is built up over these strings so that, as they leave the drum, the cake is lifted away from the cloth by the strings. The strings then pass around the discharge roller. At this point the cake is freed from the strings. The strings are then fed back over another roller to the underside of the drum.

Other features which can be added to this rotary vacuum filter include a washing mechanism, compression dewatering mechanism, scoring device for cutting the cake as required for feeding into totally enclosed driers, drum drier combinations, repuddling mechanism for thixotropic starches and special constructions such as totally enclosed housings. Filter cloths are supplied in a variety of synthetic fabrics including *Nylon*, *Vinyon-N* and *Orlon*.

An example of the advantages of using this design is given by a penicillin manufacturer who was getting wet cake, insufficient washing and recovering only 85% of available penicillin. The *FEinc* filter removed the solubles with minimum wash water, gave firm, dry cake and recovered 98% of the penicillin.

Developed by Filtration Engineers Inc., U.S.A., the *FEinc* pilot-plant rotary vacuum filter with string discharge is now being manufactured under licence in the U.K. by Stockdale Engineering Ltd.



APV-Cooper valve.

Stainless steel valve

The APV-Cooper stainless steel valve is designed for the control of corrosive liquids and gases. It is claimed to incorporate many outstanding design features, *e.g.* it offers free and unobstructed flow to liquids or gases, is positive in action, highly resistant to corrosion, sturdy in design, reliable in operation and easy to maintain.

The ball-and-socket rotating-type disc unit adjusts itself to the seats in the valve body regardless of the angle; it is self-cleaning and non-galling. The two-piece gland construction of the stuffing box is designed to provide square compression of the mica-lubricated, blue asbestos, acid-resisting packing which, in conjunction with the finely ground and polished stem and freedom from rotational movement, ensures efficient sealing and freedom from wear. The special bonnet design permits automatic compensation for expansion and contraction caused by temperature changes, without danger or damage to threads, operating nuts or valve seats.

Manufacture of the valve in England has been started by the A.P.V. Co. Ltd., using the processes and technical data of the Cooper Alloy Foundry Co., U.S.A.

The valves are said to be suitable for use in the processing of chemicals, brines, petroleum, explosives, paper and other products involving corrosive and hazardous liquids and gases. At present production is confined to gate valves in the range ½ in. to 10 in., with maximum working pressures of 150 lb./sq.in., but a series of flush-bottom tank valves of proven design is being made available.

For further information on new plant and equipment, please complete the coupon on page 390.

Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Extraction apparatus

An apparatus for contacting two immiscible or only partially miscible liquids continuously and in countercurrent, comprises a horizontal or sloping cylindrical tube 1 divided by partitions such as 5 and 6 into a series of alternate mixing spaces 2 and settling spaces 3, the mixing spaces being provided with stirrers 8 mounted on a common spindle 7, each of the two partitions dividing a mixing space from the two adjacent settling spaces being provided with an annular slot such as 9, Fig. 3,

FIG.2.

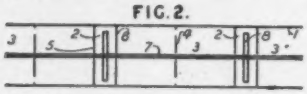


FIG.3

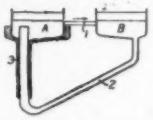
the slots extending along arcs of equal radius concentric with the centre line of the spindle or being adjustable to vary their respective levels so as to vary the net flow of one liquid from one settling space *via* the mixing space to the other settling space and the corresponding net flow of the other liquid in the opposite direction. Preferably each partition is rotatable in its own plane to vary the level of its slot, and the slots in the two partitions on each side of the same mixing space are fixed with respect to each other in diametrically opposed positions, the slots extending over arcs of 120° or less. The partitions may be fixed to the tube so that they can be turned together with the latter, the tube bearing a pointer which moves along a scale to indicate their position. The settling in the spaces 3 is assisted by partitions 4 provided with slots and perforations in their top and bottom sections. Specification 486,347 [*Group* III] is referred to.—617,626, *N/V. Bataafsche Petroleum Maatschappij.*

Polymerisation catalyst

A catalyst for olefin polymerisation comprises an oxide of iron, nickel or cobalt activated by pretreatment at 400 to 700°C. for at least ½ hr. with a gas containing free oxygen. Nickel oxide on kieselguhr, alumina, charcoal or the like is preferred. Basic nickel carbonate may be precipitated on kieselguhr, reduced with hydrogen at 300 to 400°C., and oxidised with oxygen-nitrogen containing 1 to 10% oxygen, of which a deficiency or excess may be used. Alternatively, the carbonate may be converted directly to oxide by heating in air or nickel nitrate decomposed to oxide and then activated. Polymerisation is effected in liquid or gas phase. Diluents, especially higher boiling normal or cyclo-paraffins, may be present. Polymerisation activity is increased by addition of alkali or alkaline earth metals or their alloys or amalgams, preferably in liquid state. Contact times may be 30 sec. to 12 hr. In examples a catalyst prepared by precipitating basic nickel carbonate on kieselguhr, reducing in hydrogen at 400°C., oxidising with a 2% oxygen in nitrogen mixture at 600°C., and cooling in nitrogen, is charged, alone or with purified pentane or pentane and sodium, to an autoclave in a nitrogen atmosphere, heated to 105 to 110°C. and used for ethylene polymerisation. Catalysts prepared by decomposing the nickel carbonate on kieselguhr or nickel nitrate on activated alumina in oxygen-nitrogen mixtures, followed by activation, are used similarly.—618,674, *Phillips Petroleum Co.*

Solvent extraction

In a method of separating substances by solvent extraction wherein the extracted substance is separated by lowering the temperature of the solution to below that at which the extracted substance is soluble and wherein the process is continuous, the difference in temperature between the different parts of the solvent is used to produce a circulation of the solvent. As shown, applied to the extraction of one metal from a mixture of metals, a container *A* holding a molten mixture of manganese, iron and carbon is treated with molten bismuth in which manganese



alone is soluble. The solution of manganese in bismuth separates on the surface and is drawn off along a pipe 1, which may be artificially cooled, to a container *B* at a lower temperature when the manganese separates and may be removed from the surface. The bismuth flows through a descending tube 2, and a heater 3 on a rising arm produces a thermosyphon effect to return the bismuth to the container *A*. The parts of the apparatus may be maintained at the temperatures most suitable for the process.—614,333, *Stavanger Electro-Staalverk Aktieselskapet.*

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The Silicosis Problem

INDUSTRIAL disease is no new product of the 20th century. Pliny described how workers who handled cinnabar 2,000 years ago wore respirators of pig's bladders to protect themselves from the dust. Ancient Egyptian embalmers contracted asbestosis from the material they used. The appalling incidence of silicosis among the flint knappers of Brandon, who used methods similar to those by which flints were worked into spear heads during the Stone Age, suggests that silicosis may be the earliest of industrial diseases.

Some aspects of the silicosis problem were discussed by Dr. F. Holt at a meeting of the Royal Institute of Chemistry at Reading University.

Dr. Holt, who was awarded the Consolidated Goldfields of South Africa premium for research in silicosis, is directing a research group for the British Steel Founders' Association on the silicosis problem at Reading University.

He said that dust particles which reach the lung alveoli are swept up by phagocytic cells and are removed to the lymph glands. Certain siliceous dusts induce changes in the lung and lymph glands with formation of patches of abnormal fibrous tissue. The mechanism is still uncertain. The earlier theory that the damage was mechanical was discarded when it was shown that fibrosis is not produced by quartz particles surface-coated with iron oxide. The later theory that damage is induced by silica solutions formed by the dust particles is not supported by solubility measurements made on minerals. Other theories not generally accepted take note of the special properties of quartz: the high activity of its freshly fractured surfaces, its piezo-electric properties, its effects on the tubercle bacillus and the fact that most industrial siliceous dusts also contain alkali.

Quartz and other siliceous dusts dissolve very slowly in water, no sharp maximum being obtained even after several weeks. This makes a comparison of solubilities difficult and arbitrary. Rapid exchange, complete in about 4 hr., takes place, however, between quartz and Si^{31}—labelled silicic acid solutions. The process of solution is being studied.

Quartz, like other silicate mineral, adsorbs proteins from solution and this must occur when quartz dust contacts the alveoli. Whether this property is connected with the production of fibrosis is not known, but it will certainly affect the solubility of such dusts.

Interest also centres on the silicon, which is a normal constituent of tissues. A part is contained in an alcohol-soluble tissue extract and is believed to be in organic combination. Experiments utilising SI^{31} confirm this, but they suggest that the formation of the compounds is not due to biosynthesis and can be effected *in vitro* without living tissue.

Chemical and Allied Projects at Sindri, India

THE Sindri project in Northern India, consisting today of a fertiliser factory* and its associated township, was established in almost undeveloped country but in a region where there is space for great expansion. Because of the undeveloped state of the area, it was necessary for the operation of the fertiliser factory to build a large thermal power station and to take elaborate measures to safeguard the water supply.

The future, however, presents a totally different picture. When the main Damodar Valley Corporation schemes come into being there will be ample supplies of cheap power and water in the Damodar basin, of which the Sindri area forms a part. With these facilities, and situated within a few miles of enormous reserves of coal, and within easy reach of the main E.I.R. and B.N.R. railway systems, the Sindri area is ideally situated for industrial expansion on a big scale.

To ensure co-ordinated development, both as regards industrial areas and residential areas, a master plan is being produced. If the industrial development of India follows its natural course, Sindri has prospects of becoming one of the main areas of development, particularly in the field of chemical engineering and associated heavy industries. It is not visualised that the development plan for the Sindri area will be confined to nationalised industries. The facilities mentioned above will undoubtedly attract private enterprise and the development of an integrated plan is expected in the not-too-distant future, the Government taking the lead in the case of industries where pioneering is required, private enterprise taking the lead in industries where private capital can be raised for such developments. The above is a broad picture of what might be called a long-term development plan.

The Sindri factory itself, however, has been planned to facilitate expansion to double its present size. Buildings have been laid out in such a way that, in the event of expansion, everything will be in the right place. All underground services, such as water supply mains, sewers, etc., have been installed to double capacity. Sindri need not necessarily expand on the basis of doubling the production of ammonium sulphate. The layout adapts itself for the manufacture of various other end-products such as ammonium nitrate, urea, etc. Apart from this major expansion plan, various early developments are anticipated, amongst which are the following:

1. Coke Ovens: For operation at full output the Sindri factory requires between 500 to 600 tons/day of coke, according to whether the coke has a low or high ash content. A temporary source of supply exists, but with the expansion of India's steel output, which is already under way, this source of coke will not be available after about 1953. Therefore, to meet this situation, a plan has been drawn up for the installation at Sindri of coke ovens for the production of the coke required for the operation of the Sindri factory. Apart from coke, the plant will produce various valuable by-products such as tar, motor benzole, pure benzene, etc., besides contributing a certain amount of ammonium sulphate to Sindri's already large output of 1,000 tons/day. The availability of coke oven gas will facilitate new developments at Sindri. Coke oven gas can be used for boiler firing, domestic and industrial heating, it can also be reformed for ammonia synthesis, or used for a new process now being developed for the thermal fixation of atmospheric nitrogen.

2. Cement plant: When in full production Sindri fertiliser plant will produce as a by-product about 900 tons/day of calcium carbonate sludge which can be used as the main raw material for the manufacture of cement. Complete plans have been drawn up by Government for the construction of a cement factory at Sindri. It is possible, however, that this activity may be transferred to private enterprise. The amount of sludge available, when mixed with various other ingredients necessary for the manufacture of cement, will be sufficient to produce roughly 600 tons/day of cement.

3. Methanol/formaldehyde plant: Some three years ago plans were drawn up for the installation of a methanol/formaldehyde plant for an output of 10,500 tons p.a. of methanol and 3,500 tons of formaldehyde. The character of these plans, however, has been changed by the purchase as German reparations, of a methanol/formaldehyde plant capable of producing a much larger output. The methanol plant will use waste gases from the existing gas plant as one of the raw materials for the manufacture of methanol. The installation of this larger plant is now the subject of technical and financial study.

4. Catalyst plant: For the operation of the fertiliser factory certain catalysts are required. Under present conditions these have to be imported which is a drain on foreign exchange. Plans have been made for the installation, at Sindri, of a plant for the manufacture of the catalysts required for the operation of the Sindri factory.

5. Ammonium nitrate plant. As already mentioned, the output at Sindri will not meet India's full requirements of artificial fertilisers; moreover, it is desirable to have different sorts of fertilisers to meet the requirements of different soils. Therefore, plans have been made for the installation of a plant for the production of 100,000 tons p.a. of ammonium nitrate.

6. Urea plant. Urea can be used as a fertiliser. It is also a useful raw material for the plastics industry. Plans have been drawn up for the installation of a urea plant at Sindri to produce 3,500 tons p.a.

7. Ammoniated phosphate plant. The Bihar State Government is embarking on the construction of an ammoniated phosphate plant adjacent to the Sindri fertiliser factory. Certain raw materials will be supplied by the Sindri fertiliser factory to this factory.

8. Bihar Engineering College. In the early days of the fertiliser project, the Bihar State Government were looking for a site for an engineering college. Appreciating the importance of associating technical education with practical training, the Central Government offered the Bihar State Government land adjacent to the Sindri fertiliser factory for building their college. This college has now come into being and great advantages will accrue from mechanical, electrical and chemical engineering training being carried out adjacent to one of India's major industrial installations.

The foregoing is a glimpse of future prospects. Perhaps one day the Sindri areas may be the Tees-side or the Pittsburgh of India in so far as the chemical and allied heavy industries are concerned.

*See CHEMICAL & PROCESS ENGINEERING, May 1952, pp. 247-253.

Recent publications

Gas and electric furnaces. Birlec Ltd. have recently published a four-page brochure which deals, in very general terms, with the complete range of their products. These include both gas and electric fired heat treatment furnaces, arc induction melting furnaces, induction heating equipment for both forging and heat treatment applications, and Birlec *Lectrodryers* for drying compressed air, process gases, etc., and maintaining low atmospheric humidities. A separate page of this brochure is devoted to Birlec melting furnaces which are installed in steel works, ferrous and non-ferrous foundries, die casting shops, etc., throughout the world.

Oxide ware. Details of *Triangle* pure oxide tubes, crucibles and furnace shapes are given in a leaflet from the Morgan Crucible Co. Ltd. This ware has high temperature resisting properties, the 'fused alumina' (90.91% alumina) being suitable for use with temperatures up to 1,700° C. The low silica content makes it suitable for use in contact with noble metals. Other grades are 'pure alumina' (99% alumina) suitable for temperatures up to 1,800° C. and 'recrystallised alumina' (99.7% alumina), which has high thermal conductivity, and good electrical resistivity at high temperatures and can be used with temperatures up to 1,950° C.

World News

GREAT BRITAIN

I.Chem.E. Graduates' and Students' Section officers

At the recent annual general meeting of the Institution of Chemical Engineers Graduates' and Students' Section, the following officers were elected for 1952-53: A. H. Isaac, *chairman*, D. J. Hardie, *hon. secretary*, G. D. Chester, W. E. McClelland, P. M. Shaw and F. S. Smith, *industrial members of committee*, and R. K. Baker, D. C. Freshwater and K. R. Gray, *college members of committee*.

Local committees have been formed to organise activities in the Midlands, North-West, North-East, South Wales and Yorkshire.

S.C.I. Corrosion Group

The Corrosion Group of the Society of Chemical Industry has just issued a report on its first year of existence. During the year seven meetings were held, including a one-day symposium on corrosion of buried metals, which was held in conjunction with the Iron and Steel Institute and the British Iron and Steel Research Association. A second day meeting was held jointly with the Belgian Association for Testing Metals.

The group now has a membership of 250, which is still increasing. An invitation has also been received from the National Association of Corrosion Engineers of the United States that the group should be represented on the council of that body.

An important matter to which the committee has given considerable attention is that of the training of corrosion workers and the education of engineers and others in the principles of corrosion prevention. At the Birmingham College of Technology a series of educational lectures has been arranged in consultation with the Group Committee, the lectures being given by prominent members of the group. This course is now in progress. Another, somewhat longer, course of special lectures has been arranged at Battersea Polytechnic to start in the autumn, the lectures being given, as at Birmingham, by visiting specialist lecturers. In addition, at Battersea, there is an enlightened policy of providing a regular corrosion course by a staff lecturer primarily to prepare students for the corrosion section which now enters into the curricula of both the Higher National Certificate and the Institute of Metallurgists' examinations.

Fertiliser Society officers

At the fifth annual general meeting of the Fertiliser Society, held in London recently, Dr. E. M. Crowther was re-elected as president and Mr. J. Angus as vice-president.

Another plant to make H_2SO_4 from anhydrite

A £2,000,000 plant for the manufacture of 75,000 tons of sulphuric acid and 75,000 tons of cement or cement clinker from local anhydrite is expected to go into production at Whitehaven, Cumberland, in 1954. The plant will be operated by Solway Chemicals Ltd., a new company being formed by Marchon Products Ltd. and the Industrial & Commercial Finance Corpn. Ltd., on a site adjoining the existing Marchon works, about 1½ miles from the centre of Whitehaven. Extensive borings have proved the existence of two seams of considerable thickness and quantities of anhydrite sufficient to cover the requirements of Solway Chemicals Ltd. for at least 50 years. Provision has, in fact, been made in the designing of the plant for doubling the capacity, if feasible.

The plant is being engineered and constructed by Marchon Products Ltd., aided by a number of technical consultants who include Dr. H. H. Kuehne, formerly managing director of I.G. Farben and co-inventor of the original process to be operated, known as the Muller-Kuehne process. This process is also operated by Imperial Chemical Industries Ltd. at Billingham.

The sulphuric acid is required in the manufacture of the Marchon range of surface-active agents, phosphoric acid and phosphoric acid derivatives.

In line with the new sulphuric acid project, the company are re-erecting their phosphoric acid plant. This is expected to be operating in a few months' time, producing an equivalent of 3,000 to 4,000 tons of P_2O_5 p.a. This figure is expected to be increased to 10,000 tons by 1954 when the H_2SO_4 plant goes into operation.

The manufacture of sulphuric acid on a substantial scale will probably be the beginning of development of other branches of the heavy chemical industry in west Cumberland. Most of the basic services required for these developments are already available and there are adequate supplies of coal, water and other minerals. In addition, local schools are providing suitable technical education in what was once a distressed area.

Note.—This is the second new anhydrite acid project to be started in the U.K. The first is being built at Widnes (see this journal, April 1952, p. 204).

Birlec's 25 years

In 1925, Henry Wiggin & Co. Ltd. set up an experimental department to investigate the wider uses of nickel chromium alloys as electric furnace heating elements. Two years later the success of this department justified the creation of a separate manufacturing company, and in this way Birmingham Electric Furnaces Ltd. came into existence. With the amalgamation of the Mond Nickel Co. Ltd. and the International Nickel Co. of Canada in 1929, the undertaking became the youngest member of the Inco organisation. In 1945 the company's name was changed to Birlec Ltd.

"The First Twenty-Five Years" was the subject of an address given by Mr. J. H. Crossley, Sales Director, Birlec Ltd., at a luncheon in Birmingham given to celebrate the company's silver jubilee year. In reviewing the progress, he claimed that his company was the largest organisation of its kind in the world making furnaces and allied equipment only. In addition to including completely new furnace designs, Birlec Ltd. have also pioneered new heating applications in this country—continuous furnace copper brazing, continuous bright annealing, gas carburising, to mention but three.

In addition to furnaces, the company produce *Lectrodryers*, non-chemical moisture adsorbers depending on the properties of activated alumina. These dryers are used in the chemical and process industries where dry atmospheres are required.

Institute of Material Handling

Following a meeting in London, an Institute of Material Handling has been formed, with Mr. H. P. Mott, of Vauxhall Motors Ltd., as chairman, and Mr. John Bright, of Joseph Lucas Ltd., as deputy chairman. There is a provisional council of 16 members, all users of material handling equipment, with the exception of four, who are manufacturers.

Membership of the Institute is confined to individuals, and does not include firms or corporations. Anyone engaged in material handling is eligible. Further information may be obtained from the Secretary, Mr. M. W. Paynter, The Institute of Material Handling, 20/1 Took's Court, Cursitor Street, London, E.C.4. (Telephone: Chancery 8484.)

The Unilever report

In the report for 1951 of Unilever Ltd. it is stated that, after sales of detergents in the first nine months of the year had been higher than ever before, a decline occurred in the last quarter which reduced total sales to less than the record tonnage sold in 1950. In the event, metric tonnage sold amounted to 1,217,000, compared with 1,239,000 in 1950. The decline is attributed to the world-wide trade recession. On the other hand, sales of margarine and edible fats rose from 1,117,000 metric tons to 1,167,000. Sales of food rose from a value of just over £70,000,000 to nearly £96,500,000, and of toilet preparations from £17,400,000 to £20,000,000.

The report states that world production of oils and fats in 1951 was slightly higher than in 1950 and nearly 2,000,000 tons greater than before the war. However,

owing to increases in world population, the quantity available per capita was still 1.1 lb. p.a. below the pre-war level of 22.3 lb.

Vegetable oil prices dropped sharply in 1951. The following figures show the peak prices of 1951 compared with those ruling in April 1952: Copra (Straits), £145, £60; whale oil, £175, £80; palm oil (Congo), £207, £72; tallow (New York), £146, £40; and cotton oil (New York), £213, £98.

Unilever's research facilities are being expanded to meet the needs of the business as it develops. New laboratories have been built in New York at a cost of $3,500,000 and will be ready shortly. Existing research units in the Netherlands are to be rehoused and expanded. Changes designed to place greater emphasis on development work are being made at the research department, Port Sunlight. A new laboratory to serve the company's interests in the field of toilet preparations is to be established in the London area.

Total turnover was £1,205,000,000 for 1951, compared with £989,000,000 in 1950. Consolidated net profit was £18,800,000 in 1951, against £19,200,000 in 1950. The ordinary dividend of 13½% for Unilever Ltd. and 12% for Unilever N.V. accounted for £2,914,000 and was the same in 1951 as for the previous year.

Institute of Fuel

Dr. G. R. Foxwell is to serve as president of the Institute of Fuel for a second year. During the session just completed, Dr. Foxwell as president has addressed meetings in Birmingham, Bristol, Cardiff, Derby, Glasgow, Leeds, Manchester, Newcastle and Sheffield, and taken the chair at all meetings in London.

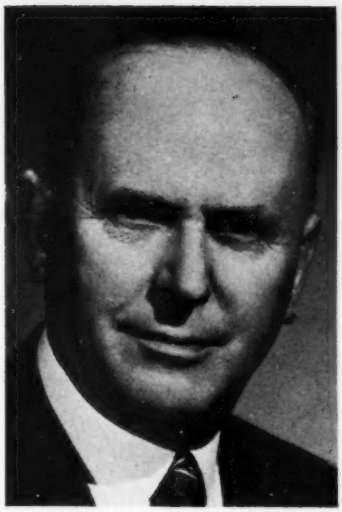
The Institute of Fuel, although granted its Royal Charter only in 1946, now has 4,000 members.

Sulphur from flue gases

Asked in Parliament what progress had been made in the matter of sulphur recovery from gases from coke ovens, particularly those owned by the steel industry and by the National Coal Board, Mr. Strauss said that plants were now under construction for the recovery of some 10,000 tons of sulphur annually in the form of sulphuric acid. Other projects were under consideration.

New pyrites-acid plant

The large new pyrites-burning sulphuric acid plant at the Sandilands Chemical Works of Scottish Agricultural Industries Ltd., at Aberdeen, is scheduled to begin operations at the end of 1952. When in full production the factory will have an annual output of 37,000 tons of 100% sulphuric acid, which will meet superphosphate needs in northern Scotland. The company plans to double the output of the sulphuric acid plant at Carnousie, which also uses pyrites.



MR. W. LINDSAY BURNS

who has been executive head of the Balfour Group of Companies for many years, was appointed chairman of Henry Balfour & Co. Ltd. at the recent annual general meeting held at Leven, Fife. For some time he has been vice-chairman of Henry Balfour & Co. Ltd., chairman of George Scott & Son (London) Ltd., and Ernest Scott & Co. Ltd., and vice-chairman of Enamelled Metal Products Corporation (1933) Ltd.

Despite difficult conditions he was able to report another highly successful year. New plant had been installed to reduce production costs still further and it is hoped to erect additional workshops. Despite the restriction on raw materials, output has not been curtailed in any way.

Mr. Burns paid a further visit to Canada in May where he has already been developing the company's interests.

Symposium on chemistry of cements

An international symposium on the chemistry of cements will be held at the Royal Institution of Great Britain in London from September 15 to 20 under the sponsorship of the Department of Scientific and Industrial Research and the Cement and Concrete Association of England. All interested persons are invited to attend. Information can be obtained through the secretary of the symposium, 52 Grosvenor Gardens, London, S.W.1.

Lead £4 dearer

The price of good soft pig lead was increased from £129 to £133 per ton, delivered consumers' works, from June 24.

Glass-enamelled plant shown

In conjunction with their German associates, Pfaudler-Werke of Schwetzingen, Baden, Enamelled Metal Products Corp. Ltd. exhibited their Pfaudler glass-enamelled steel equipment at the recent Achema Exhibition in Frankfurt. The products shown included a 300 gal. glass-enamelled reactor with all accessories, and a 4 in./3 in. glass-enamelled flush valve with porcelain seat.

Personal

Mr. M. K. Schwitzer, author of the book "Continuous Processing of Fats" published last year by Leonard Hill Ltd., London, has recently returned from a 20,000 miles trip to South America, Mexico and the U.S.A. On behalf of Bamag Ltd. he visited a number of firms interested in British chemical plant and has in particular made a thorough study of the vegetable oil industry in Mexico. In the U.S.A. he visited several of the most up-to-date oils and fats processors and had an opportunity of comparing American and European methods.

Dr. R. H. Griffith has been appointed by the Gas Council to be the Director of the London Research Station and by the North Thames Gas Board to be their Controller of Research. He replaces Dr. H. Hollings who relinquished his appointment at the end of June.

GERMANY

I.G. Farben successor companies

The Allied High Commission has now published the regulation which lists 12 successor companies and their subsidiaries of the former I.G. Farben Chemical Combine. The companies are the Agfa Camerawerk A.G., Munich; Badische Anilin und Sodafabrik A.G., Ludwigshafen; Casella Farbwerke Mainkur A.G., Frankfurt; Chemische Werke Hüls, Marl, near Dusseldorf; Farbenfabriken Bayer, Leverkusen; Farbwerke Höchst (formerly Meister, Lucius und Bruening), Frankfurt; Titangesellschaft, Leverkusen; Duisburger Kupferhütte, Duisburg; Kalle und Co., Wiesbaden; Dr. Alexander Wacker Gesellschaft für Elektrotechnische Industrie, Munich; Dynamit A.G., Troisdorf, near Bonn; and Wasag Chemie A.G., Sythen/Ruhr. Under the regulation, the tripartite I.G. Farben Control Group is authorised to cause the transfer of former I.G. Farben assets to the successor companies and their subsidiaries. The regulation further provides that the control group may create or reorganise additional companies or subsidiaries of these and issue orders or take any action necessary to carry out the provisions of this regulation.

Herr Adenauer has stated that the West German Government would ensure that the chemical combine would not be formed again and that none of the 12 successor companies of the combine would merge before December 31, 1955. Not even 'working agreements' or contracts to take over profits or losses would be permitted. The Government would only make an exception if any of the companies should get into a position where its existence as an economical enterprise was seriously threatened. The main successor companies—Farbenfabriken Bayer A.G., the Badische Anilin- und Sodafabrik A.G. and the Farbwerke Höchst—would under no circumstances be permitted to merge with one another.

European chemical engineering committee formed

A permanent European working committee for chemical engineering was formed at the European Congress for Chemical Engineering which was held at Frankfurt-am-Main in conjunction with the recent Achema exhibition of chemical apparatus. The members are Dr. H. Bretschneider, managing director of the German Society for Chemical Apparatus; J. Gerard, vice-president, Société de Chimie Industrielle, Paris; Dr. F. A. Freeth, a former vice-president of the Institution of Chemical Engineers, London; and Dr. L. Morandi, Italy.

Synthetic phenol to be produced

The Scholven-Chemie A.G. hydrogenation firm and the Ruetgerswerke A.G. have founded a joint company to produce synthetic phenol. The Scholven management said a new method using benzol and by-products of crude oil processing will be employed.

FINLAND

First vegetable-oil factory

The first Finnish vegetable-oil factory, owned by Oy Kasviöljy-Växtolje AB, is expected to go into operation this summer. The pretreatment and pressing plant, supplied by Miag, Germany, has a capacity of 100 tons/day of rapeseed. The building housing this plant is large enough to allow later expansion to 200 tons/day. The 150 ton/day extraction plant is being supplied by Bamag Ltd., London. This is the first extraction plant to be installed in Finland and it is expected to be in operation this summer. The refining and hardening plant, also to be supplied by Bamag, has a capacity of 40 to 45 tons/day and is expected to be running next year.

The pretreatment and pressing plant comprises grinding roller, continuously operating expellers, crushing and flaking rollers. About 20% of the oil content will be expressed and the remainder will be solvent-extracted. The extractor is a continuous Bamag-Manning horizontal extractor with a multi-stage solvent circulation system. The refining plant will comprise a continuous neutralising section, batch bleaching unit, hardening, and deodorising sections.

NORWAY

Cement industry prospers

Norway's largest cement factory, Christiania Portland Cementfabrik, recently celebrated its 60th anniversary. Since the war the factory has spent £1,500,000 on extending its capacity, and production is now about 350,000 tons a year, or almost half the total Norwegian production of cement. Although Norway is now producing about twice as much cement as before the war—720,000 tons in 1951 as against 332,000 tons in 1938 and 390,000 tons in 1939—demand still exceeds supply, and cement is one of the few commodities still rationed in Norway. It is estimated that the consumption of cement per inhabitant has increased tenfold in Norway since 1900. An increasing amount of the factory's production is now being transported in bulk and special vehicles deliver cement in bulk loads of 10 tons direct from the factory to building sites.

YUGOSLAVIA

Cement and chemical industries to be developed

The $28,000,000 which Yugoslavia has received as first instalment of a loan from the International bank will be used to buy equipment for 45 Yugoslav factories, collieries and industrial projects.

Some of these enterprises, already in existence, are being enlarged and modernised, while others are under construction. Some of the equipment will be imported, while the remainder will be produced in the country.

Equipment will be bought for eight cement factories which will raise annual production by 430,000 tons.

Production increases as a result of the new investments are estimated at 46,000 tons of chemical pulp and paper, 12,000 tons of electrolytic zinc, 22,000 tons of sulphuric acid, 4,000 tons of glass and 3,000 tons of ceramics.

SWEDEN

Plastics industry's difficulties

The Swedish plastics industry is encountering difficulties owing to German and British competition and to sales' resistance, according to trade circles here. Some factories may have to close down for a time. At present there are 250 plants with a total of 5,000 to 6,000 employees in Sweden. About 60 to 70% are small firms, and it is mainly these which are expected to cease operations.

INDIA

Japanese interest in iron ore industry

Japan and Germany are competing for a share in the development of India's iron industry by supplying machinery and technicians for a new pig-iron plant to be set up in Orissa. The Indian Government is understood to be considering proposals both from Japanese firms and the German firm of Krupps, which recently sent a delegation to India.

It is believed, however, that although German terms are favourable the Indian Government is likely to accept the Japanese offer, since Japan is interested not only in the supply of capital goods in the shape of blast furnaces and foundry equipment but needs also to import as much iron ore as possible from India. Germany, on the other hand, is interested in supplying machinery but does not need to import Indian ore, since the long-distance transport would make the cost prohibitive. Japan is reported to be ready to invest 70,000,000 rupees into the projected pig-iron plant, which will be at Sambalpur, Orissa.

Salt output to be expanded

The government of Orissa has requested the co-operation of Imperial Chemical Industries Ltd. in its programme for expanding salt output in the state, and two British technical experts have surveyed salt-producing centres at Surula and Sumanda. In addition to the manufacture of salt from sea water, the government envisages the establishment of a chemical industry to make caustic soda, bleaching powder, chlorine and other products when cheap hydroelectric power is available from Hirakud. I.C.I. experts will investigate these possibilities.

SOUTH AFRICA

Sulphuric acid plant to be converted to pyrites

Plans to convert one of the two contact sulphuric-acid units at its Umbogintwini plant in Natal to pyrites are being made by African Explosives and Chemical Industries, Ltd. It is estimated that the conversion will take about 27 months. The company may increase the capacity of the other unit to maintain sulphuric acid output during the change-over; total production capacity of the plant is 150,000 short tons annually. The decision to convert to pyrites is considered a significant step towards the Union's self-sufficiency in sulphuric acid. The Umbogintwini plant is expected to be converted entirely to pyrites within the next few years and then the only sulphur-burning units will be two at the company's factory at Somerset West.

Fertiliser costs are expected to increase after the change-over because of the additional capital expenditure required, the greater cost of pyrites, and the problem of disposing of the cinders, for which African Explosives has not been successful in finding a market.

CANADA

New potash plant planned

Plans to build a potash plant which would be ready by the beginning of 1954 have been announced by the president of the Western Potash Corpn., Toronto and Calgary. The plant would mine Canada's only known potash beds, located over an area of 120,000 acres in the Unity district, for which the company holds leases. A large American firm is also interested in acquiring mineral rights for recovering potash in the district, the president announced.

MEXICO

European equipment for newsprint mill

European equipment is being purchased for a newsprint factory on which construction is to start this year. Initial investment in the plant, which is to be built near Temosochio, in the northern state of Chihuahua, will amount to 30,000,000 pesos. According to the Secretary of National Economy, the plan is not a new one, but it has now become essential to manufacture newsprint in Mexico in view of the price being paid for newsprint imports.

In order to ensure supplies for the manufacture of pulp, the Government has announced the prohibition of exports of timber from Chihuahua and the remainder of north-west Mexico during the remainder of this year and the whole of 1953. In recent years Mexico has drawn most of its newsprint supplies from Canada. Imports from that country have averaged about $3,500,000 annually.

JAPAN

Acetylene derivatives produced

The Arai plant of the Dainippon Celluloid Co. Ltd. has been in operation since 1935 and manufactures principally acetylene derivatives. Its basic products are calcium carbide, acetic acid, acetic anhydride, cellulose acetate, vinyl chloride, ethyl acetate, and vinyl and butyl acetate. New installations are modern in design and layout, and the research department is said to be active.

PHILIPPINES

Steel industry developments

A venture by the Philippine Government and private enterprise into steel manufacture has produced an industry whose present output target is 150,000 tons p.a. The development of the industry, and of engineering industries to absorb its products, is intended to cut the Philippines bill for imports of steel and steel manufactures, now running at approximately 300,000,000 pesos yearly if invisible imports in the form of ships' repairs done outside the country are included.

At Punta, Santa Ana, the first rod mill of the Marcelo Steel Corp., which in January started production of steel reinforcing bars ranging in diameter from ½ to 1 in., is turning out rods at the initial rate of 10 metric tons/8-hr. shift. A second unit started operating before the end of June. The Marcelo mill represents an investment of over 6,000,000 pesos and consists of three electric arc furnaces, an ingot-rolling mill and a scrap re-rolling mill. Annual production of the entire mill is expected to be 40,000 metric tons, which would be far in excess of Philippine consumption of nail wire and reinforcing bars. Surplus output could either be exported or diverted into manufacture of other light structural steel products.

In addition, molten steel is being produced at the Engineer Island shops of the Government-owned National Shipyards and Steel Corp. The present unit produces one ton of steel per heating period. A unit with a capacity 4½ times that erected on Engineer Island is planned for Camp Overland near Iligan, Lanao, where cheap hydro-electric power will be available.

Engineering enterprises set up to use the new steel output include the new 2,000,000 peso plant of the Ysmael Steel Manufacturing Co. on Espana Extension, which will turn out a large range of rolled steel appliances including refrigerators, ranges, water heaters and office equipment.

UNITED STATES

Inflammability limits of gases

The most comprehensive listing of the limits of inflammability of gases and vapours in air or oxygen yet made available in a single volume is contained in a recently issued U.S. Bureau of Mines bulletin. It is expected to be useful to research organisations and industrial concerns using inflammable gases or volatile liquids in planning the ventilation systems of their laboratories and plants so as to minimise explosion hazards. The types of installations affected range from coal mines and metallurgical plants to hospitals and dry-cleaning establishments.

Inflammability limits of gases and vapours are the upper and lower percentages of a gas or vapour which will form an explosive mixture with air or oxygen. For instance, under ordinary circumstances, a mixture of methane with air is inflammable if it contains between approximately 5 and 14% methane. If the air-methane mixture contains less than 5 or more than 14% methane it loses its inflammability, although a mixture at the upper limit may become inflammable on contact with outside air owing to dilution of the methane content.

The new bulletin, which contains 155 pages and 63 figures, explains how inflammability limits are determined and some of the theoretical considerations taken into account in such experimentation. It also presents the results of a critical review of all figures published on the limits of inflammability of combustible gases and vapours when mixed with air, oxygen or other 'atmosphere.'

Natural gas is raw material for new chemical plant

A $50,000,000 plant for the production of chemicals from natural gas is to be built by American Cyanamid Co. near New Orleans, Louisiana. It will consist mainly of outdoor type process units.

As initially projected, the plant will produce ammonia, acetylene, hydrocyanic acid and derivatives of these products, among them acrylonitrile and ammonium sulphate. These basic materials provide a foundation for the eventual production of a wide range of both hydrocarbon and nitrogen chemicals for industrial use and for agricultural purposes. Acrylonitrile is a basic ingredient of the firm's new synthetic wool-like fibre *X*-51 and acrylic fibres produced by others. It is also used in making synthetic rubber and plastics, and its use in a wide range of agricultural products including soil conditioners, is being investigated by numerous firms.

The Louisiana site offers many advantages, including natural gas, ample process water from the Mississippi River, excellent transportation by river, road and rail, a favourable climate, nearby markets in the textile and rubber fields, and a good source of workers.

The Leonard Hill Technical Group

Articles published in some of our associated journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist—Adhesives, Part 1; Pearl Essence; Progress Reports of Chemotherapy, Cosmetics, and Fertilisers.

Food Manufacture—U.S. Canning Industry from 1940-50, Part 3; The Bath-Oliver Biscuits; Chemistry and Physics of Macaroni Products.

Petroleum—The Elektrion Process; Petroleum Progress in South America.

Paint Manufacture—Examination of Varnish-Making Vegetable Oils; The Earliest Known Paints; Ford Viscosity Cup Tests.

Atomics—Notes on the Use of Geiger-Muller Tubes; Atomic Power; Radioactive Sugars.

World Crops—Tobacco Growing and Processing; Southern Rhodesian Tobacco Industry; Research in the Field of Tobacco Cultivation; Egyptian Cotton Industry, Part 2; I.C.I. and Jealotts Hill Research Station.

Muck Shifter—New Oil Dock at Eastham on the Manchester Ship Canal; Annual Conference of the Incorporated Plant Engineers.

Building Digest—New Methods of House Construction, Part 3, Steel, Timber and Composite Methods; Domestic Heating, Part 3, Air Heating Systems and Central Heating; More Mechanisation means more Houses, Part 3, Large Housing Sites.

Textile Industries — New Dutch Process for Drying of Sisal; Outstanding Textile Machinery at Recent Trade Fairs.

Pottery and Glass—Tercentenary of the Bristol Pottery.

'Alfin' catalyst rubber

A new Canadian process for making super-tough synthetic rubber, promising tyres which would better withstand high-speed driving in hot climates, was described at an American Chemical Society meeting in Cincinnati. Dr. H. Leverne Williams of the Polymer Corpn. Ltd., Sarnia, Canada, said the new rubber might be useful in articles for which GR-S, the present general-purpose synthetic, was not good enough, particularly large-size truck and bus tyres and products of the 'gum rubber' types. Such items, he said, must be extremely flexible and, therefore, could not be strengthened with large amounts of reinforcing materials such as carbon black.

The process is based on the *Alfin* catalyst—a chemical agent that can rapidly transform butadiene into rubber. This was first described in 1948. But the chief drawback of *Alfin* rubber then was its remarkable toughness, which made it difficult to process into tyres and other products.

It was predicted then that *Alfin* rubber might eventually replace all natural rubber and GR-S in motor vehicle tyres and that further research would find a way to process it. The latter prophecy, Dr. Williams said, had been fulfilled through the use of the oil-extension principle, developed in 1949 and 1950 for use with 'cold rubber.' It had been found possible to prepare the *Alfin* rubber in the presence of an oil not unlike a light lubricating oil, so that the resulting oil-rubber mixture was easy to process and use and still retained its good properties.

The addition of a substantial proportion of oil, he added, also meant a saving in raw materials of up to 30%. The toughness of the new rubber suggested that even higher percentages of oil than were used with cold rubber might be feasible. Other cost reductions in the *Alfin* process might be possible through large-scale, continuous production of the rubber, instead of the time-consuming processes now in general use, he stated.

Laboratory experiments suggested that relatively inexpensive, commercial-grade raw materials could be employed in the process both for the manufacture of the catalyst itself and for the rubber, Dr. Williams declared. Savings in manufacture were also possible because the process could be carried out near room temperature, making the expensive refrigeration of the cold rubber process and the costly heating employed in other processes unnecessary. 'Production at Sarnia is still in the laboratory stage, but we understand that similar polymers (synthetic rubbers) are being prepared by the United States Government laboratories at Akron, Ohio, in a small pilot factory,' he added.

Silicone plants enlarged

The U.S. General Electric Corpn. and Dow-Corning Corpn. (the latter is jointly owned by Dow Chemical Co. and Corning Glass Works) are to expand production facilities for silicones. The former company is to spend about $5,000,000 on the installation of additional improved equipment in its present Waterford, New York, plant, with the new equipment scheduled to be in production in a few months' time. The latter company is spending around $13,000,000 to expand its chemical production facilities and general plant services to make silicone fluids and resins, as well as *Silastic*, a silicone rubber. Completion of this expansion is scheduled for 1954.

New chemical targets

To meet the continued sharp expansion in the demand for synthetic ammonia, the Defence Production Administration has set a production target for January 1955 of 2,930,000 tons, or 90.3% more than in January 1951.

Other programmes under consideration call for increasing capacity for the production of sebacic acid to 25,000,000 lb. by 1955; sodium chlorate to 145,000,000 lb. by 1955, an increase of 77,000,000 lb. over 1951; synthetic cryolite to 50,000 net tons by 1953, and synthetic cyanide to 91,600,000 lb. by 1955.

Iso-octyl alcohol plant planned

A large iso-octyl alcohol plant is to be built at the Wood River refinery of the Standard Oil Co. by the M. W. Kellogg Co.

The plant is divided into three basic parts: a fractionation system for obtaining heptane from an olefin feed stock; a refinery gas reformer for the preparation of hydrogen and carbon monoxide; and the actual iso-octyl alcohol section where the heptane, hydrogen and carbon monoxide are synthesised into the end product. Process design for the last-named unit will be Standard's. The other two sections will be Kellogg designs.

A primary use of iso-octyl alcohol, to be produced by the new plant at an annual rate of about 10,000,000 lb., is in the manufacture of plasticisers.

New polystyrene

A new modified polystyrene said to be a compromise between regular and high-impact polystyrenes both as to cost and make-up has been developed by the Koppers Co. The product is named *Koppers MC* 401 and is available in all standard opaque colours but not in crystal or translucent. The company say that the product was developed to satisfy a need for a thermoplastic which would have intermediate properties. They claim it is much tougher than regular types of polystyrene. At the same time, mouldings made with it are smooth and acquire a surface lustre nearly equal to that of regular polystyrenes. Its price will be only 1 cent. lb. higher than that of other polystyrenes.

International Conferences

July 7-12. Seventy-first annual meeting, Society of Chemical Industry, Aberdeen, Scotland.

July 7. International conference on safety in mines research, Ministry of Fuel and Power, Safety in Mines Research Establishment, Buxton, Derbyshire.

July 8-15. Congress of the seventh session of the International Union of Theoretical and Applied Mechanics, Istanbul, Turkey.

July 14-17. International Institute of Seaweed Research symposium (papers on phycology; algal chemistry; harvesting technology; utilisation in industry, medicine and agriculture; seaweed resources, their survey and conservation), sponsored by the Institute of Seaweed Research, Edinburgh, Scotland.

July 14-19. Midland Region Summer School on industrial electronics, Electrical Engineering Department, the University, Edgbaston, Birmingham 15.

July 21-27. Second international congress of biochemistry, Paris, France.

August 4. Second international congress on analytical chemistry, Oxford.

August 6-8. General discussion, 'The Physical Chemistry of Proteins,' the Faraday Society, Cambridge.

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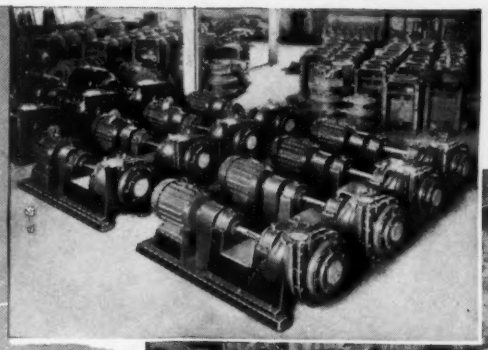
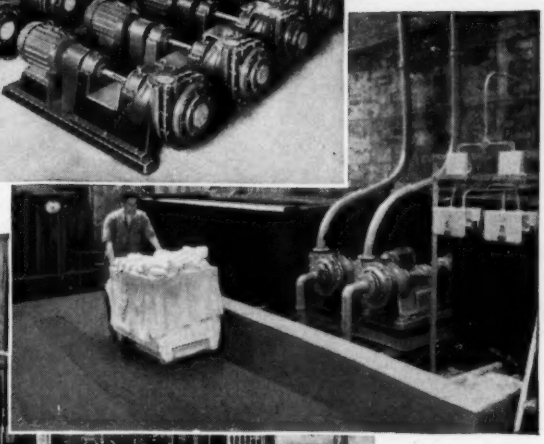
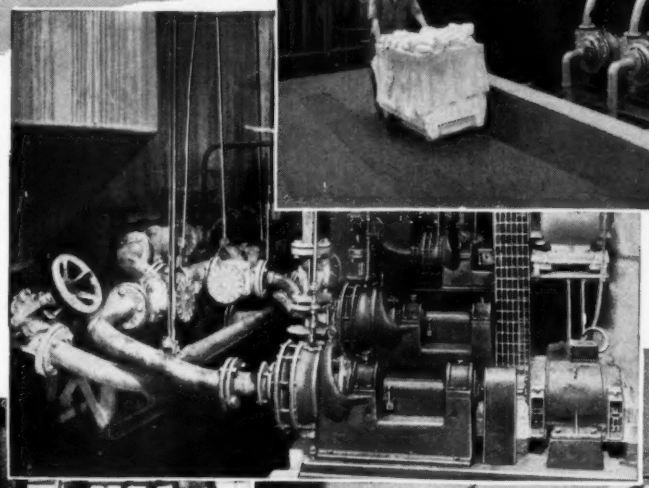


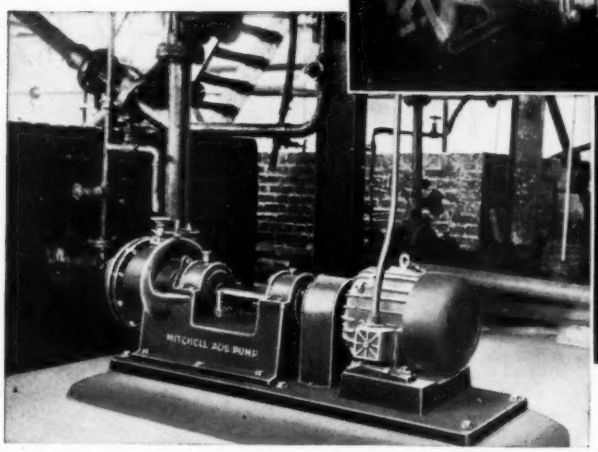
Centrifugal pumps and parts of pumps in the shops.



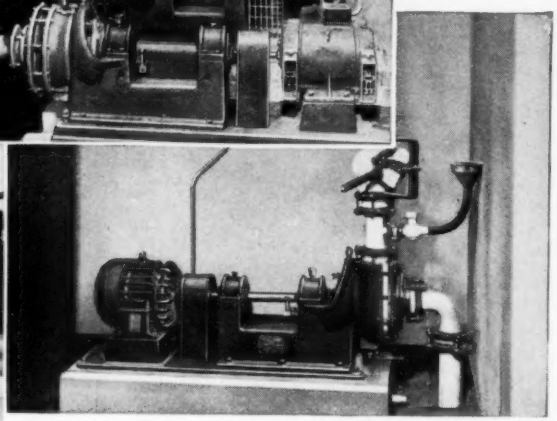
Above : Two Mitchell pumps installed at a textile factory.



An installation at a large Titanium products factory.



Mitchell acid pump installed in a chemical works.



Mitchell acid pump on duty at a large textile factory.

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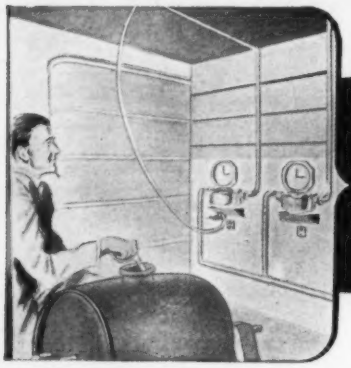

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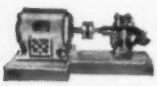

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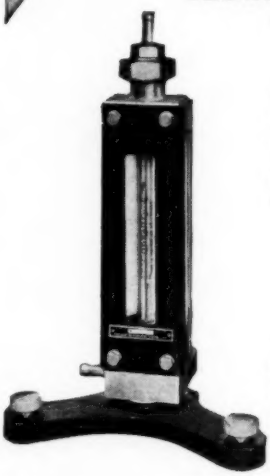

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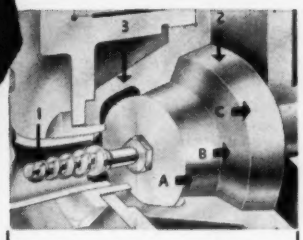

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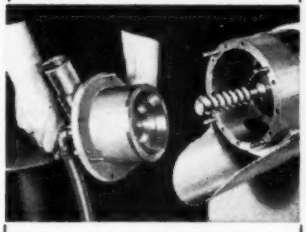

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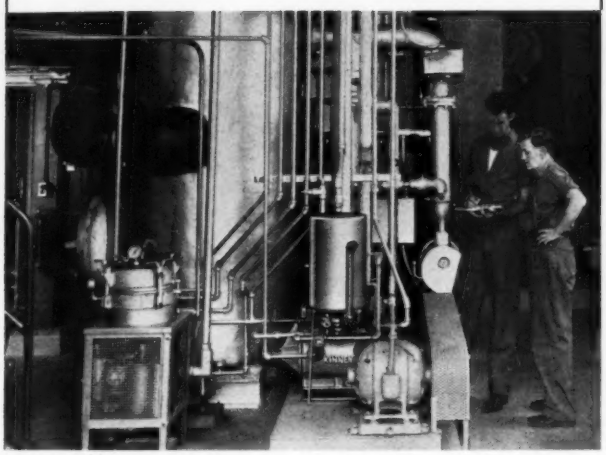

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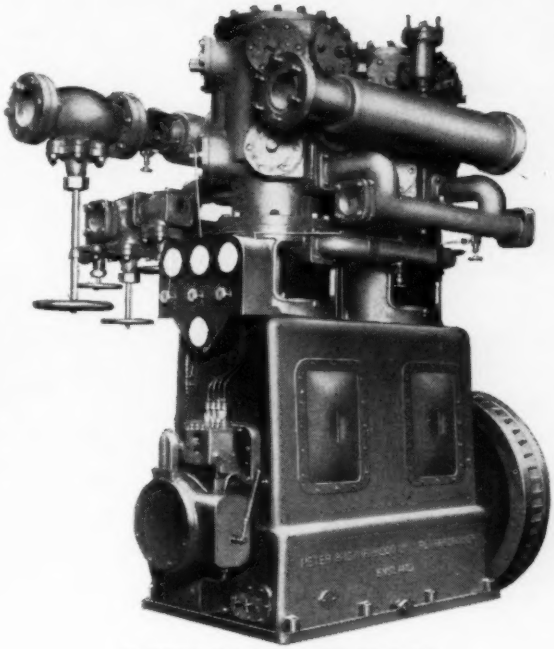

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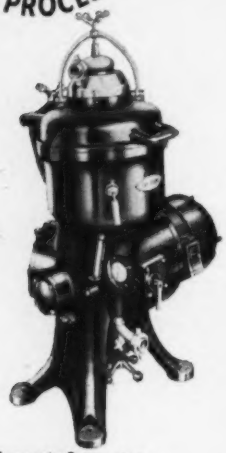

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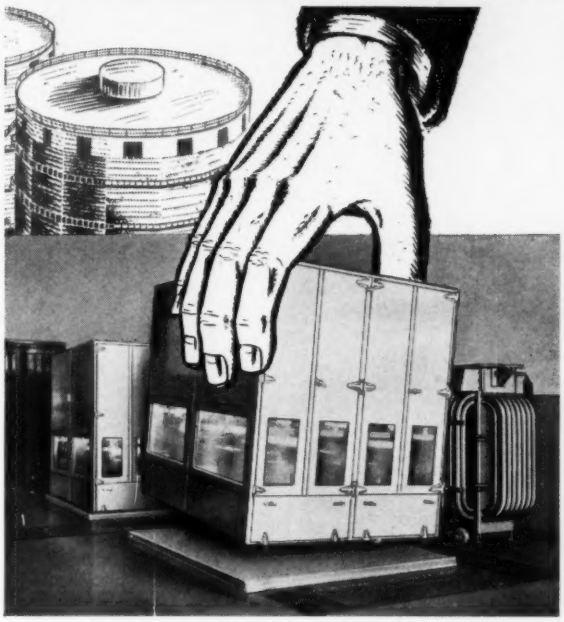

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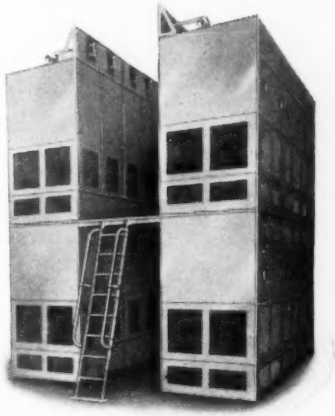

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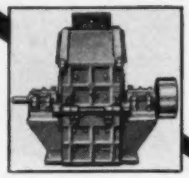

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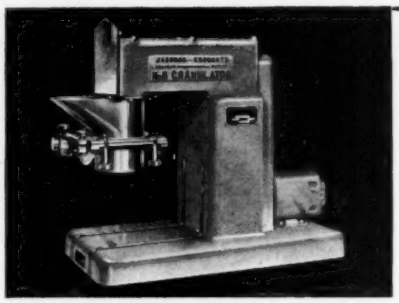

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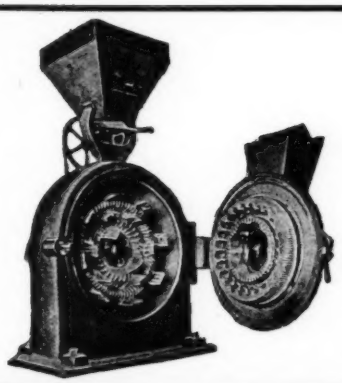

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